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DECEMBER 1997

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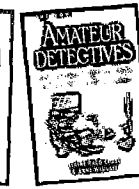

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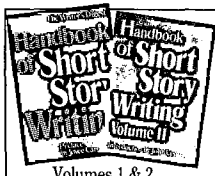

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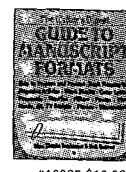

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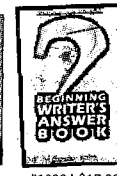

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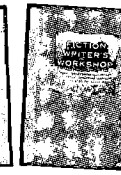

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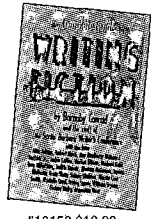

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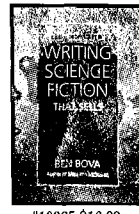

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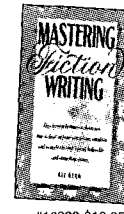

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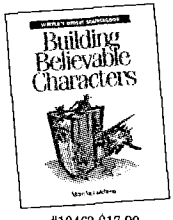

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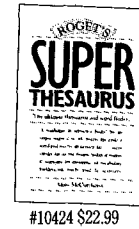

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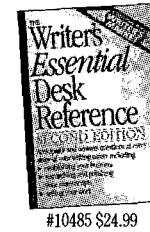

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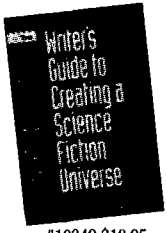

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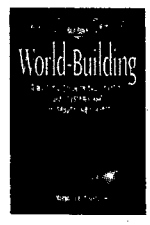

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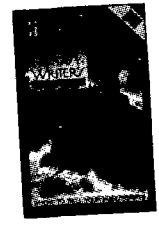
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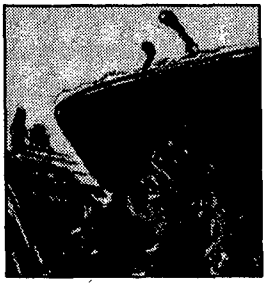

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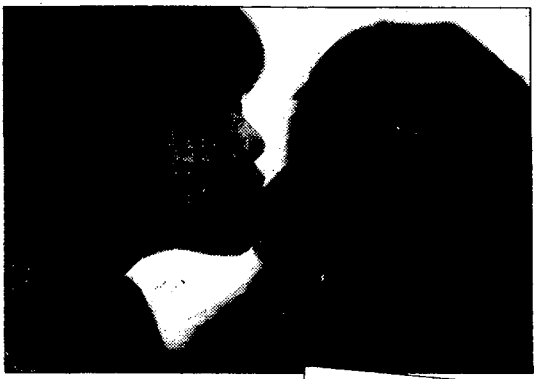

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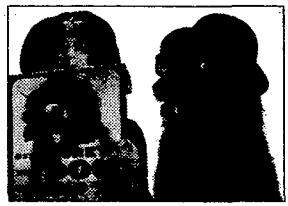

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E PLURIBUS *HOW* MANY?

The compulsion to choose This *or* That, and to assume that the choices are *a priori* mutually exclusive, seems to run very deep. I've commented on it before, in connection with such disputes as whether heredity *or* environment determines intelligence and character. It's understandable, I suppose, in people who haven't thought much about how to discipline their thinking. But the tendency is surprisingly prevalent even among professional scientists.

An interesting recent reminder of this fact was the announcement in the April 29, 1997 New York *Times* of a new hypothesis advanced to explain the geologically sudden demise of many species of large mammals, from saber-toothed cats to mastodons, in North America about 13,000 years ago. Scientists have been arguing for quite a while about what caused this unusual event. Until recently, the two leading contenders were the "climatic change" and "Blitzkrieg" hypotheses. The first, as its name suggests, maintains that climate fluctuations during the Pleistocene period destroyed habitat, shrank ranges, wiped out food supplies, and otherwise reduced populations of the megafauna to unviable levels. The second is a bit less obvious: The mass extinctions, occurring shortly after the first humans reached the continent, were a direct result of humans overhunting animals which had not learned to regard them as a threat.

The new candidate, put forth by mammalogist Ross D.E. MacPhee, also blames the arrival of humans, but in a different way. The real culprit, according to Dr. MacPhee, was not hunters' spears and the native animals' naïveté, but diseases carried by humans and the other animals (such as dogs, rats, and parasites) that accompanied them.

It's a good, sound idea, the kind that might make you wonder, "Why didn't anybody think of it sooner?" We already know, from more recent migrations, that when a group of immigrants move into an area where none of them have been before, they *do* bring pathogens for which the locals have not had occasion to build up immunity, with results including widespread mortality.

However, we also know that the climate *was* fluctuating wildly during the Pleistocene, and that animals whose ancestors haven't had to contend with humans *do* tend to be unafraid of them, which is a seriously

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nonsurvival trait. (Consider, for example, the Galápagos when Darwin first got there.)

So what fascinated me most about the *Times* article was not the new hypothesis, but the fact that almost all of the article was devoted to the ongoing arguments among proponents of the three hypotheses about which one was The Answer. The article contained some 43 column inches of text. Only in the last six inches was the possibility that the extinctions had multiple causes even hinted at, and then it was pretty much shrugged off. "Some scientists," wrote the article's author, William K. Stevens, "see the idea of multiple causes as a kind of intellectual cop-out. It is better, said Dr. MacPhee, for one, to 'develop and test hypotheses singly and then they either succeed or fail singly.'"

Well, sure, if you can establish that a single, simple explanation actually does the job, fine. Go with it; don't muddy the waters with irrelevant extranea. But if there are other *relevant* factors, it may be an intellectual cop-out to ignore them, to pretend that they aren't there or aren't important. Sometimes a correct hypothesis *has* to include several components and a description of how they interact.

Suppose you're the first person trying to explain what causes avalanches. If you spend years trying to determine whether it's the pull of gravity *or* the steepness of the slope *or* the physical nature of the snow, you'll get nowhere. No one of those factors alone will cause an avalanche. No matter how strong the gravity, a level field of snow will just sit there. Even on a very steep hill, snow that is tightly packed and welded together by thawing and refreezing stays put, while light, dry powder is easily dislodged even on a fairly gentle slope. But any of a considerable number of right *combinations* of those factors *will* start an avalanche, every time. And if you change any of the factors in a way that prevents it, you can change one of the others in a way that will still trigger the slide.

One biologist cited in the *Times* article on Pleistocene extinctions objected to the disease hypothesis on the grounds that, in the words of the article, "It would add another mechanism, in addition to hunting, by which humans instigated the extinction of so many species." It seems to me that this argument overlooks the distinction between a theoretical scientist adding a mechanism, and na-

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ture adding a mechanism. He's quite right that it's bad science to keep inventing *ad hoc* hypotheses, cobbling together an elaborate structure to explain what you can't explain with a simpler one. But it's also bad science to disregard a mechanism that you already have reason to believe existed and could contribute to the effect you're trying to explain, just because it would complicate your explanation.

In the case of the Pleistocene megafauna extinctions, we *do* have reason to believe that all three proposed mechanisms did exist and almost certainly caused increased mortality among the species in question. So why is almost everybody trying so hard to prove the extinctions were caused solely by some *one* mechanism? Why not just try to determine the extent of the effect each had, and what, if any, synergistic interactions they had? I have a strong suspicion that if the various contenders ever get around to doing that instead of trying so strenuously to prove the supremacy of their own pet theories, they'll find that each is a correct *partial* explanation, but none is complete.

Climate changes almost certainly *did* make life harder and wipe out some of those critters. Slaughter by hunters with lots of cultural experience, going after animals who had no experience in developing healthily defensive attitudes toward them, probably did, too. So, I suspect, did the introduction of new diseases against which the resident animals' immune systems had no defenses. It seems to me eminently likely that no *one* of these influences killed enough animals to wipe them out, but being hit by all of them at once was more than they could withstand.

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Disregarding the notion that anybody is motivated by the desire to get credit for coming up with *The* Explanation for anything, I assume that all of the people working on the extinction problem, each pushing for a different Single Cause, are guided by the well-known principle often called Ockham's (or Occam's) Razor. William of Ockham, a philosopher writing in the neighborhood of 1300 A.D., phrased it (in Latin) as, "Entities are not to be multiplied beyond necessity." Twentieth-century scientists have often stated it in more pragmatic terms such as, "If two or more theories explain the data equally well, go with the simplest one."

Ockham's Razor is a sound and frequently useful principle, but it's a philosophical "rule of thumb," not a rigorous law, and as such cannot be used to *prove* anything. It's more a handy guide to choosing which models to use than a means of determining which, if any, of them is "true." It's perfectly possible to describe the motions of the planets and their satellites, with a high degree of accuracy and predictability, with a complicated system of Ptolemaic epicycles. Ockham's Razor says, "Why bother, when you can get the same result with Newton's much simpler model of universal gravitation and laws of motion?"

Newton himself was applying Ockham's Razor when he postulated that the gravitational force between the Earth and the Moon was the same as that between the Earth and an apple. But it is *not* the same as the dominant force (electromagnetic) between an electron and a proton. (The number of fundamental principles in physics is, however, amazingly small, when you think about it; and a good deal of physicists' energy in this century has gone into trying to reduce it still further by finding ways to view apparently different phenomena as aspects of the same thing.)

Physicists, at least in the big picture, are in the business of trying to formulate the simplest possible set of *general principles* that can be used to explain and predict—everything. The biologists studying the Pleistocene extinctions are trying to determine just what happened in a single, isolated, and unusual event. It's a good idea to bear in mind that any real event can be caused by the simultaneous action of two or more "simple causes." The more unusual the event, the more likely it is that it *was* caused by a synergistic combination. If one simple factor would do it, it would happen oftener.

And while Ockham's Razor is a useful reminder that you shouldn't make your life (or anybody else's) unnecessarily complicated, neither should we forget its corollary: Don't be afraid to let entities multiply to the extent that *is* necessary. Given multiple possibilities, it isn't always necessary to "Pick Just One"—and sometimes you can't. ■

A great faith can attract mediocre apostles.

—Samuel C. Florman

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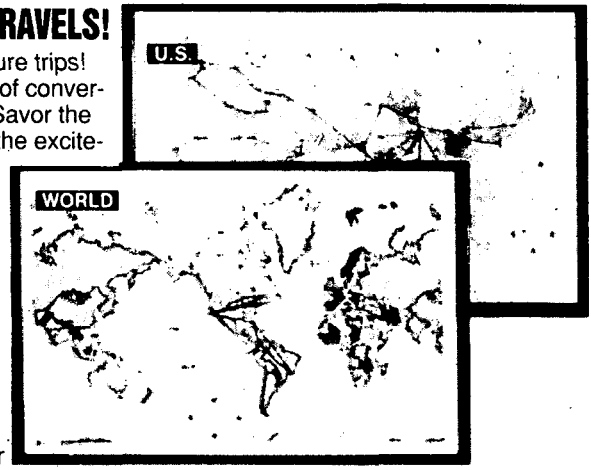

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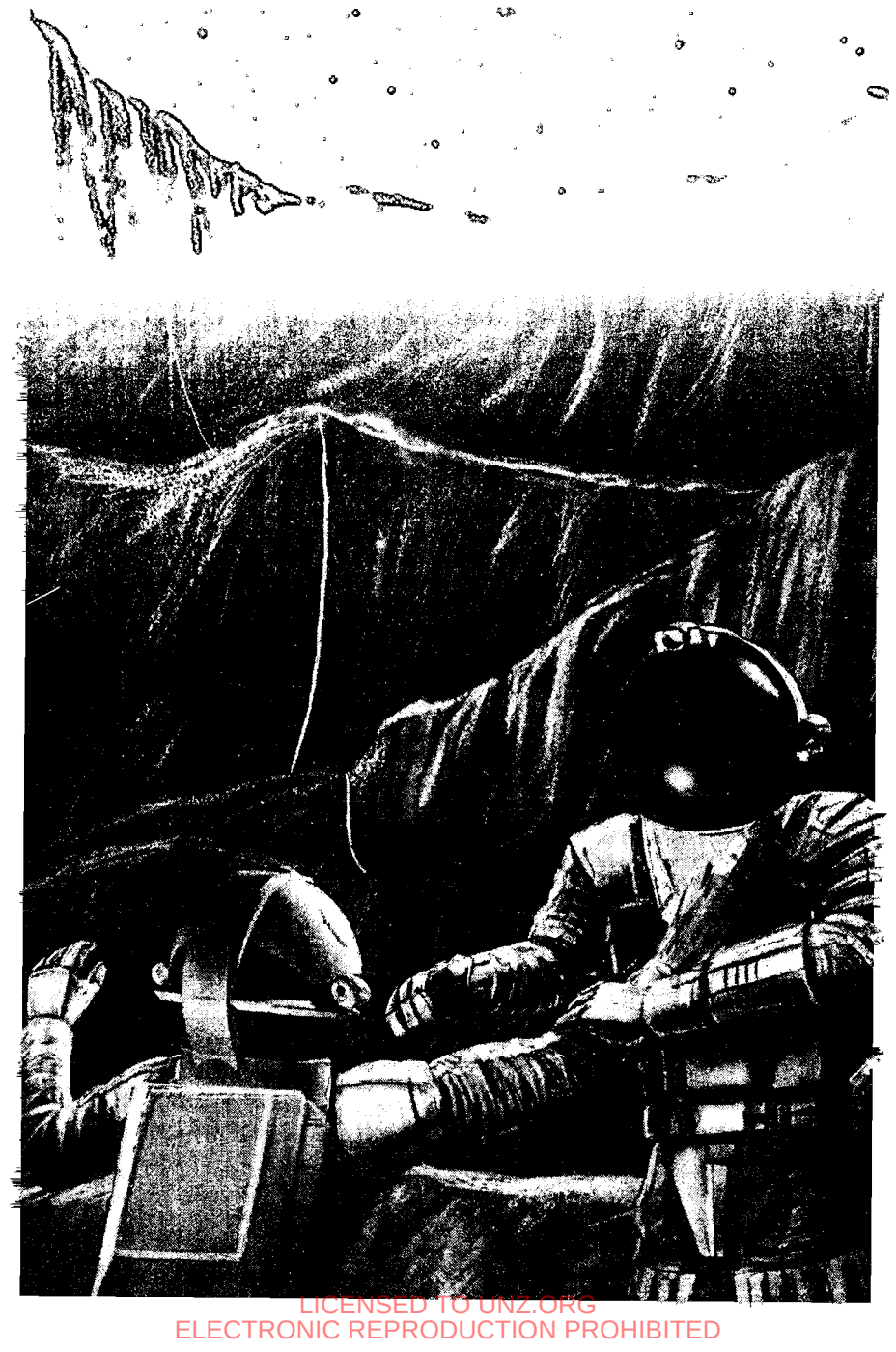

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G. David Nordley

CROSSING CHAO MENG FU

Our first close glimpses of
our neighbor planets have shown them
full of surprises.
And the closer we look . . .

Illustration by George H. Krauter

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Begin a ghostly plain
Dim white in pale starlight.
Flat as far as you can see
To where a distant black ridge
Divides reality.
Above the stars shine
Below the ground crunches;
Hillary, Byrd, Peary and Amundsen,
Are your guides. It is beautiful.
But you cannot stop long;
The plain is life itself;
Move on now, trod onward,
Or stand and freeze, they say.

—W.B.

I am in the middle of a line of people walking determinedly across the most everything-forsaken boring waste in the Solar System. I am so sore and tired I could scream—if there were a warm bed around somewhere, I'd crawl in it to shudder. My attitude has hit rock bottom, but it is time to file my report and if I want anything good out of this pain, I'd best sound positive:

"I am Wojciech Bubka, college teacher, occasional poet and now your . . ." I take a breath of sterile suit air, ". . . guide to the natural universe, courtesy of the Solar System Astrographic Society and its many sponsors and members. Welcome to my personal journey through exotic, dangerous, and unusual places of the Solar System." I take another deep breath—got to keep up with everyone else. "Come with me while there are still such places to explore—for as we approach the twenty-third century, this frontier, too, is receding."

I try to gain a little ground to stop briefly and pan my helmet cam over the dirty ice field. Despite the exertion, the change of pace lifts my spirits a bit. But not even a ten-to-one vertical exaggeration will make this landscape interesting. Come on, Bubka. You're a poet? Find meaning.

"These are not robot explorations to be experienced in a video display, but personal ones. I seek authentic, not virtual, reality. I seek the *go there, see there,* and *be there* experience of the human explorer, not sterile pixels." Breathe deep. "There is nothing between me and the crunch of crampon spikes on this frozen mud, the strike of an axe into virgin scarps, the strain of muscles, the hiss of sliding ropes, and the sight of wonders. Such is the dream and the experience I seek to share with you here, today, on the frozen wastes of Chao Meng Fu crater on Mercury."

Said strain of muscles gets my attention as I start walking again, and I groan involuntarily. I am tired from the almost week of walking under a pack that brought my weight close to Earth normal—when what is normal for me is Mars. I wiggle my toes as hard as I can—despite vacuum insulation, thermistor environmental control and loose, fluffy socks, I think my feet are beginning to get cold.

"Come on, mate. Another hour will get us there." That is Ed Blake, a gentleman adventurer from New Zealand with Antarctic experience. Ed is my tentmate, lanky, mostly bald and prematurely gray, confident, competent, and reserved—unless he gets that kind of twinkle in his eye. Then beware a terrible pun. He's cheerful enough to me, but I sense a certain condescension.

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Understandable, I think. What the frozen hell am I doing here?

I had been getting bored at Jovis Tholis University. Poetry, these days, includes video as well as text—something which would have delighted Will Shakespeare, I assure you—and has blended with drama so much that we distinguish the two by picking nits over length and symbolic content. But even in its media-inflated majesty, a dozen years of going over the same basic stuff while fighting battles with New Reformation censors and left-wing nihilists—neither of whom take kindly to the display of material contrary to their philosophies—has me well on my way to burnout.

JTU is in a dome over an ostensibly extinct volcano on Tharsis, roughly halfway to Olympus Mons from the tether tube terminal on Ascraeus. The location worked, and it became the biggest university on Mars—of which I was an increasingly small and out-of-step part.

As the politics of being an important academic became increasingly burdensome, my dreams of "out there" grew. I might teach at Saturn High Station with its magnificent view of the rings. Or I could compose random meter verse at Hyperion institute, the lonely retreat of mathematical philosophers set on a detached mountain peak that careens about Saturn as metaphor of an uncertain future. Or I could volunteer to ride a comet and watch robots turn it into Martian air while writing my epics in the freedom of isolation as the comet fell for a decade into the inner Solar System. Or, and this was my most favorite, I might become a journalist in the old sense on the first expedition to Pluto and Charon.

Thus did I dream. But so, of course, dream millions of others. Only a chosen few can go anywhere the first time or do anything the first time. I dabbled at trail writing; journals of hikes and visits to parts of the vanishing "Red" Mars, but got little notice beyond a reasonably nice "been there, done that" rejection from the Solar System Astrographic Society. I needed an entree, a contact, an idea, something to lift me out of the background.

Then, last year (Martian year, everyone; almost two standard years ago), Miranda Lotati, the daughter of the man in charge of Solar System Astrographic Society's expeditions division, walked into my literature class at Jovis Tholis University, a junior transfer from Stanford on Earth. She looked to be a hard, vigorous, and exciting person but could barely choke two words out in succession—about as contrary to stereotype as one could be and still have breasts.

She was not really beautiful—too muscular, too thin in the face, too boyish a figure, but I saw the possibilities in that. Less competition, and perhaps a complement to my esthetic, well, softness, I told myself. I saw the romance of an attraction of opposites who themselves were opposites of conventionality, and I was looking for some romance somewhere—the women of my normal circles were hopeless and helpless in anything but words, and even seemed to take pride in that. I saw in her an invitation to be-

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yond and away from here. If I played it right—and I resolved to do so.

It wasn't easy. Miranda was a rough-edged, prickly student, and her essays were condensed dullness, never more than the required length. A spoken sentence of more than a half dozen words was a rarity from her, and she sometimes seemed to speak a language so far evolved from today's English in its lack of articles and verbs that, had it been deliberate, would have been considered art in some circles. Nonetheless I was intent. I persisted in bringing her along. I bided my time.

I had to expend some moral capital, but convinced myself that she covered the ground on her final well enough to let me pass her. She liked me, I think. But I said nothing unethical to her, nor hinted at anything romantic while she was my student—I have my standards.

I saw her on the last day of classes of the winter semester, after the final grades were in.

"You're off to Mercury, I hear, to be along on your father's attempt to walk across Chao Meng Fu Crater?" Shielded from the Sun, that huge crater was an ice field—Mercury's Antarctica.

She nodded.

"Have you set the expedition membership?"

She shook her head, confirming what was known publicly.

"Will you have any journalists along? It would make a very exciting nature piece."

She smiled a bit. "Like your Ascraeus Mons hike piece? Dad liked that and sent me here."

He'd seen that? I tried to remember the rejection letter. I was flattered but a bit worried that it was a little light for a Lotati expedition. Then the alarm bells rang in my head. My competition for the position of expedition bard was standing in front of me.

I reached for a tone of professorial authority. "Randi, uh. You've come a long way in your composition . . ."

She shrugged. "Yeah. Thanks to you. Someone's got to do the article. Someone who fits on the team. Wish I wrote better."

"Randi, I suppose I shouldn't be obscure. Is there any chance I might come myself?"

Her eyes lit up for a moment, then she frowned. "Rough business, exploring."

"Then my accounts of it should draw interest, maybe enough to push Solar System Astrographic's allocation priorities a little further up." Not to mention that a single Astrographic article could bring in the equivalent in allocations of my entire Jovis Tholus University stipend for a year. A *Martian* year.

"Uh, huh." A doubtful assent on her part

"Might even help you get to your namesake, out by Uranus. Now there would be an angle that people would notice!"

That got her attention. "Dad's idea too. My name. Not that easy, though. No place for amateurs, out there."

I smiled at her. "I bet I'll make a good explorer. I'm observant, handy, and in reasonably good shape."

She gave me a somewhat skeptical look and a sigh. "Mercury first. Chao

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Meng Fu. Hundred fifty kilometer-wide. Never sees the Sun. Covered with granite-hard permafrost. Probably take us two, three weeks to walk it."

"Walk?"

She nodded. "Unassisted. Carry everything. Vacuum suits, tents, supplies, samples."

"Walk it? Uh, why?"

She looked at me as if I was born in some other cosmos. "Because we can."

There is this recklessness about me that allows me to throw words around without fully considering the consequences. "Well, I think I can too. I've done enough hiking around Tharsis—I even have a cinder cone named after me."

She looked skeptically at me. "Oh? How high?"

She had me there. I grinned sheepishly, "Well, 'Bubka Mons' is only a hundred meters above local mean. But it's kind of impressive because there's nothing else around it." And I knew someone in the Martian Geology Institute that was laying out the local real estate.

She giggled.

"It *is* registered, Randi. Anyway, my Ascraeus trip was solo, and by a new route."

She looked judiciously at me and sighed. "Lose ten kilos. Do fifty kilometers a day." We stood silent for a couple of seconds as I tried to digest that.

She turned away. "Physics final—see you." And she was gone, gliding easily down the hall.

Dreams are free; but realizing them has a price. And I resolved to pay it.

* * *

By the end of last semester, I had walked up a few Martian mountains and lost the ten kilos. I talked to her again and we arranged a checkout hike down to the base of Jovis Tholis and back up to the town again with full packs, breather gear, and by the most difficult route she could pick. She watched every move I made, and seemed satisfied enough to make another "date."

As this went on, I grew utterly fascinated with her. She was a busy woman. Reporters called her, outfitters called her. She was always meeting young women explorers who knew her reputation as a companion of her father, and old men explorers who had been somewhere with her father. My metaphor for Randi was a black hole; people and things seem to swirl around and accrete to her without any significant verbal effort on her part, as if her presence distorts space so that all roads simply lead to her and none away.

The week she was to leave Mars for Mercury she called me.

"You're in, Professor Bubka. Can you make the Shannon inbound? Friday?"

By moving heaven and Mars, I could, and did. I had, it seemed, been within her event horizon for some time now.

So, Mercury. Mercury gravity is the same as Mars gravity, which some say is more than a coincidence, but a coincidence as yet unexplained. The gravity here is exactly the same as on Mars, but I'm carrying three times my mass in supplies and vacuum survival equipment. I might as well be hiking

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in Antarctica with a light pack. Indeed, I could use the conditioning to visit Earth! Despite the extra mass, we try to keep up the fifty kilometers a day—a pace I must maintain.

There are eight of us strung out along the Chao Meng Fu crater floor, Dr. Lotati in the lead. Dr. Juanita Tierzo, a Harvard-trained geologist, follows him. Juanita is actually on the JTU faculty—in the Martian Geology Institute—but I had to come to Mercury to meet her. Randi follows her. Then comes Ed, myself, and one of Dr. Tierzo's graduate students, Eloni Wakhweya, a slight Kenyan woman with a big grin. Solar System Astrographic expedition staffers Mike and Karen Svenson come last, pulling an equipment pallet on two large wire wheels.

They meant it; no robots, no powered vehicles, and in my now humbled opinion, no sense. If Mercury had a breathable atmosphere, they'd have done without the spacesuits and all their built-in communications and amenities, too. I'm exhausted, uncomfortable, and increasingly uneasy with this exercise in cosmic hubris.

The view is simple, unrelieved flatness, the kind of view that should reach one's soul in the way of all great expanses. The crater's stark lines go its namesake's art one spareness better; the vertical dimension is almost absent. It too is painted in an ink of five colors, all gray. It is Aldrin's magnificent desolation, without relief. I appreciate it more in intellectual abstract than in person.

There is light to see: the tips of the peaks behind us blaze like distant arc lamps, and fill the bowl of Chao Meng Fu with a ghostly kind of moonlight. Small, rounded crater rims dot this frozen plane—very few higher than a man, for ice flows in time. The brighter stars shine down on us hard and free. Brilliant Earth hangs just over the horizon, a tiny dazzling blue-white star. Luna lies well away from it, a faint gray dot lost in Sagittarius.

Invisible to us in the Earth's glare is the beginning of Earth's Sunshield. This mammoth project will partly shade the heat-polluted atmosphere from the fires of Apollo's chariot someday. It is taking form at the Earth-Sun L-1 point, balanced there with the help of reflected light—they plan to reduce insolation by 1 percent. But more relevant to our endeavor is that it is the home of Solar System Astrographic's solar radio antenna, which we use to apprise the rest of the Solar System of the status of this madcap adventure. I look that way wondering why I ever left.

"Another five kilometers to the crevasse," Dr. Lotati tells us on the comnet.

This desolate flat sameness is an illusion; we have real work ahead. The crevasse is a major obstacle, or a major objective if you are a geologist. Halfway between the rim of Chao Meng Fu crater and its central peaks lies a huge crack in the permafrost caused, they think, by an almost infinitely slow lifting of the crater floor, still rebounding from the billion-year-old impact that formed the crater. To this poet, overhead views make the crevasse looks like the mouth of the planet—and I worry about being devoured.

* * *

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By noon, universal time, the mouth of Mercury yawns directly in front of us, an ugly black crack that makes the dark gray plain around us look silvery by comparison. We halt to plan our crossing. Juanita proposes that we simply go down into this thing, down into a darkness that has never known the Sun, and out again on the other side. That idea creates enough interest to scare me. But not now. A descent will take planning, and, in the meantime, I luxuriate in not having to move my body.

Yet, standing still, I forget my pain and become curious. The crevasse seems to run to the horizon to my right and left. The other side is the length of a football field away. I shudder—it is impossible to repress the thought that such darkness is not meant for human beings, that the laws of physics will become conscious and punish us for trying it. Perversely, the challenge of that danger attracts me.

Yet, there are reasons to go down beyond the simple thrill of it. Solar Astrographic's expedition is half stunt, half science—and here is where the other half gets its due. There is a mystery here and the root of it lies in a contrary mysticism of celestial dynamics. Here, a mere sixty million kilometers from its fiery photosphere, are surfaces that have not seen the Sun since the Caloris impact defined Mercury's final orientation.

This same counterintuitive magic then decrees that the ices of comets that orbit impossibly far—beyond even Pluto, Charon, and Persephone—are actually closer to the Sun, and Mercury, in the *energy* of their motion than anything in the inner Solar System. Something on Venus would have to be kicked at almost 11 km/s to reach Mercury, best case—but merely nudge a pair of Oort belt comets together and parts of them may fall into Mercury, decades hence. Sometimes these collisions give the planet a very temporary, tenuous atmosphere, which condenses in the deep freeze of Chao Meng Fu. Blame this on Kepler and Newton, not Ptolemy.

So near is far, and far is near, and the crevasse yawns from 'ere to 'ere. Does it have teeth? Do its open jaws reveal molecules from the beginning of time, such as measured in the Solar System? Lotati confers with his daughter, and Ed. Randi and Ed have a thing, I've found, and spend a fair amount of time touching helmets.

What great ideas I have! I despair of ever being able to itch again, let alone going to Miranda with its namesake. My rented vacuum gear fits like the skin of a hundred-year-old man; stretched taut digging into my flesh here, loose and bulging there. Randi says there's an art to it and I should take more time getting in. Next time I will.

I edge closer to the brink, attracted to the danger perhaps, or perhaps wanting to demonstrate courage to Randi. I gaze down. Here and there the dust has fallen from the sheer ice walls, and the layered structure is clear. There are Mercury's sediments. Each comet or meteor creates a temporary atmosphere for Mercury, and that which is not boiled away by the Sun condenses in the polar craters, mixed with ejecta dust. The bedrock

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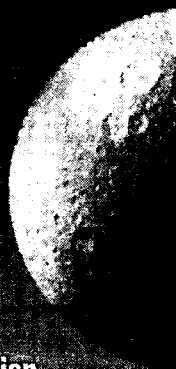

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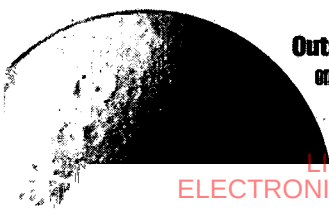

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lies perhaps a kilometer below us. After three days of the most physical labor I've done in decades, I now contemplate a rappel down to the bottom of a bottomless crevasse and the climb back up again.

I look away as though by not observing it, I can create the possibility that it does not exist.

But I have my journalist's duty. At my command, my helmet camera plays back the view, and it floats, reflected off my face plate, against the stars. It doesn't fit in the standard field of view, I realize, so I look over the edge again and slowly turn my head from horizon to horizon. An object of professional interest now, it begins to lose some of its scariness for me.

Bubka's prescription for fear of something—study the hell out of it.

How long and wide! Then I turn off all my lights, let my eyes relax, and turn back to see the solar corona, a peacock's tail of icy fire spreading from the Sun that sits just under those utterly black mountains that ring our horizon. If Chao Meng Fu did not flatten Mercury's globe here, we would not be able to see those mountains this far into the trek, so close is Mercury's horizon—but we have been heading ever so slightly inward, downhill, as well as south.

The furthest streamers of the corona glow far above that rim behind, looking almost like the aurora borealis back on Earth. Awed, I step back, and back again to catch my balance.

I happen to glance down—my boot is barely centimeters from the edge of the chasm.

"Bubka, freeze." Randi's voice echoes in my helmet.

I am already frozen.

"Now. Raise right hand," she continues.

I am carrying a strobe lamp in my right hand so I automatically start to raise my left—

"Your other right!" she snaps, instantly.

This time I get it right, raising both my arm and the strobe lamp.

"Now lean *that* way. Walk slowly. Away from edge."

I understand now: if I teeter, she wants me to teeter in the direction of safety. I walk away from the edge with as much dignity as I can muster, as if there were nothing at all wrong, knowing that anyone monitoring my heartbeat will know that I am anything but calm.

She detaches herself from the management group and strides toward me, ghostly dust glittering in my helmet light behind her footsteps. She halts in a cloud of fairy sparkles, grabs my hand, and leads me well away from the edge of the crevasse.

"Professor Bubka, near crevasses, tether. Always, always, tether."

"Professor" hangs in my mind dripping with irony. On Mars, I taught her literature. Here, I am her student—and I had just come close to failing a test where failure is judged somewhat more harshly than at Jovis Tholis University.

Nodding ruefully, I pull a piton gun from my pack and harpoon the planet. A test pull shows that it's secure, and I clip the line to my belt. Randi fires a piton in too, clips on, then clips another line between her belt and

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mine. "Ed, some baby-sitter you'd make! Going to take a look."

"Sorry, mate. Watching, Randi."

Baby-sitter?

"Now, Professor Bubka. Let's go look." Dark eyes, on a tanned face with a snub nose, twinkle at me behind the clear, non-reflecting visor.

We retrace my footprints together. We walk to the edge together. This time, I think to clip my strobe light to my belt as well.

One of the things I see is half a footprint at the edge of the crevasse. The toe half. Mine.

What I had done was, I realize, foolish, but I think I am forgiven. She pulls on her line, then actually leans out over the cut, to inspect its near side.

"Light." The word is a request and a command. Crystals from far down glitter in response.

Nervously, wrapping my line around my left hand and playing it out through a "smart slot" belay device, centimeter by centimeter, I lean out with her and shine my strobe on the wall under us. On a clean vertical, the layering resembles a diffraction grating—fine thin grooves, perfectly horizontal, broken occasionally by what must be the sections of ancient buried craters.

The strobe light looks continuous, but contains off-pulses for range—it times a journey of the absence of light. So. The crack goes down, a hundred meters, two hundred, three hundred. At five hundred, I can no longer see the light returning, but it can. I swing it slowly from side to side, as my helmet display paints a graph of angle and range. The walls seem to almost converge about twelve hundred meters below us here, with some flatness between them. I move the beam a bit to the left.

There is something across the chasm at eight hundred meters, just to our left. "Randi?"

"I see it. Bridge. Dad, channel seven."

"I have it, Randi! I'll think that is a billion years down if it's a day! What do you say, Juanita, my Randi's found a bridge!"

There seemed no point in immediately explaining that I'd found it.

"Eight hundred meters down and all the way across! Can we do it?" Juanita answers, thrill in her voice. "Do we have enough line?"

"Yes and yes," Randi's father answers after a moment of thought. Then he points to a slight dip almost above the bridge. "Probably half of an old crater, broken by the crack. That will get us a few meters closer. We could rappel down from there. Perhaps two billion years down, if the crevasse goes to the bottom of Chao Meng Fu. Do you want the bottom, Juanita?"

"God, yes, Emilio, if it isn't too dangerous."

Dr. Lotati shrugs. "It has been this way for millions of years of impacts; the walls should tolerate a few ants crawling on them. We'll go ourselves, instead of waiting for some robots to do it."

I look across the chasm for the other half of the ancient crater, but, like the other half of my footprint, there is no sign of it. Where did it go? I feel a curiosity as powerful as any hunger. What formed the bridge? What lies at the bottom? We shall find out, if the Laws of the Universe let us.

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We all have some climbing experience, but only the Lotatis and Ed have very much. It is, however, a very easy climb down in 38 percent gravity. The ropes are well secured to the plain above, the slope is usually less than vertical. Mike and Karen Svenson will remain on the rim with the bulk of the equipment until we are all safely down. They call themselves the "human robots" and have been in excellent humor. When Randi and Dr. Lotati scale the other wall, they will fire a rope across. The Lotatis will then pull over a larger rope on which a tram will carry the equipment. Meanwhile, at the bottom, Dr. Tierzo will supervise sample gathering by the rest of us. That is the plan.

It becomes dark quickly as we descend. The sky contracts to a starry band overhead, one edge of which glows a faint, frozen, shadowy pearl, a reflection lit by a reflection of sunlight on distant peaks. We turn on our helmet lights, and their glare banishes any other source of illumination. They spread sparkly pools of light on the wall—tiny crystals everywhere. I am conscious of a fine mist or fog, just on the edge of the perceivable. Our suits allow the skin's waste gases to diffuse slowly outward, our footsteps create microscopic dust clouds on which it may condense, our helmet lights evaporate hydrogen gas that has condensed on the wall. Our progress appears tinged with the ethereal.

We are three hundred meters down: a football field on end. The descent is easy, simple, routine. You ease rope out under friction, take a pair of steps down, and ease out some more. This descent is demanding and terrifying. You dare not lose concentration. Pitons can pull out, crampons can slip, and you will be just as dead from a fall of a kilometer in Mercury's gravity as Earth's. Yes, it will take a few seconds longer and an academic might note that you hit with less velocity—only about five times instead of fifteen times what is needed to smash your helmet and the skull within it.

You dare not cause problems for everyone else. One foot after another.

A person in fear of his or her life needs no more excitement—but if you want it, you glance at the wall in front of you, at layers of ice laid down when dinosaurs were young. This is not on a screen, not a simulation, but never-seen-before reality that puts ice hard in front of your own eyes.

"Ed," I ask, "do you wonder if anyone might have been here a billion years ago?"

"Eh? Interesting thought, that. The feature would attract someone with enough curiosity to build spaceships, I should think. But the crack itself wouldn't be that old, now, would it?"

"No, I guess not." When the layers were laid down, of course, this had been a part of the plain.

Still, my eyes scan every layer, hoping.

"Has everyone got positive pressure in their suits?" Dr. Lotati asks, and receives chuckles. "There is," he continues, "a significant build-up of nitrogen gas, and a bare trace of nitrogen triflouride, which I would not recom-

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mend breathing."

I call up a temp display and find that it is cold in the crack—about eighty kelvins, versus a hundred twenty at the surface. As I think about it, I notice traces of frost on the outside of my gloves: our insulation is that good. I have no idea what the biological implications of nitrogen trifluoride are, but I would rather someone else perform the experiments. A drop rolls down my face plate.

"Watch your footing, Juanita," Dr. Lotati says. "It's slippery here."

So far, my crampons dig into the dirty clathrate walls with ease, but I can tell it is wet. The wall is mostly ice, but ice that is heavily mixed with crater ejecta, pocked with more volatile ices, and stiffened far harder than anything on Earth by cryogenic temperatures. Dr. Lotati says it's something like sandstone, but if it weren't for the gas in the ice, it would be like concrete. There are few cracks, but the piton gun works well, as does the ax.

"Nitrogen trifluoride data," I ask. Floating in the wall, by virtue of my helmet display hardware, are glowing numbers telling me that nitrogen trifluoride is liquid over a range of about 80 kelvins—from about 77 up to 145—which is over 120 Celsius degrees below the freezing point of water. Somehow, stating such temperatures in kelvins above absolute zero is less scary than using negative Celsius degrees below freezing. The vapor pressure of this big, heavy molecule is almost nil at the low end of this temperature range—a wet vacuum.

A hundred meters to go, and I can see the bridge clearly in the shifting pools of our helmet lights.

"A sliver of wall appears to have detached itself and slid down until it jammed," Dr. Tierzo tells us. "The top is a jumble with, here and there, flat spaces that may have been part of the original surface, including part of a crater. I wonder if that's what knocked it down?"

"Hello down there," Karen Svenson calls. "Yes, that crater would explain what looks like a ray network around where you went down. Now that I know what I'm looking at, this spiderweb network of cracks is a real giveaway."

I hadn't remembered any cracks. I ask my suit to play back my recording of our approach to the side. The surface in the depression was smooth. My pulse races. "Playback two hours ago," I command. In a ghostly video window, my suit shows me almost falling in to the crevasse, but . . .

"Hey, everyone!" I shout. "Those cracks weren't there before. Dr. Lotati, I've got it on channel six."

There is a moment of silence.

"Quickly now," Dr. Lotati speaks briefly and very businesslike. "Those of you still on the wall come down as quickly as possible without panic and without yanking on anything. Mike and Karen, set another belay well back of the cracked area."

I have my full attention on climbing down, gingerly as possible. Dr. Tierzo is off belay just below me. I remember to lock my crampon spikes *out*—the bridge is slippery.

Meanwhile, Dr. Lotati has set an ice bolt in at the far end of our bridge. Dr. Tierzo sets another one in the biggest

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hunk of bridge she can find at our end and pulls the line tight.

Then I am off the wall. I quickly clip my line to the bridge line and release myself from the wall ropes. "Off belay."

Miranda Lotati and the grad student, Eloni, are still on the wall.

I hear, I think, at very low frequency, a kind of groan.

"We have the protection in," Karen says. "The cracks are larger!"

"Wojciech can get your line, Ed," Dr. Lotati says, "release from the wall immediately!"

"No worry. Here." He tosses me the end of his spare line and I hit it with the loop of a smart 'biner, which opens, takes the line, and shuts faster than I can see—like that old magic trick with hoops. I take up the slack.

Ed releases and scrambles off the wall, holding the taut line for balance until he reaches me. We move further down the bridge.

"Come on Eloni," Ed says encouragingly. The young Kenyan woman is the least experienced of our group—she descends slowly, but flawlessly, a few meters right of where Ed came down. "Toss me the end of your spare line."

She stops to find it. Miranda Lotati's feet are but a few meters above her. I hear another groan.

"Come on . . ." Ed says again.

Finally, Eloni tosses a coiled line toward Ed. It jerks short and dangles below her, a hopeless tangle.

"Sorry, I try to do this too fast."

"That's OK, mate," Ed says. "Just come on down now. We'll improvise."

We feel a slight tremor. She freezes.

"Down, Eloni. Fast," Randi says.

Eloni starts moving again. I can see her tremble.

"Ice!" Karen shouts. Our radios level amplitude, magnifying whispers and buffering shouts—that shout was well buffered.

Eloni freezes.

"Go," Randi snaps, and clips Eloni's helmet with the side of her boot. "Get going!"

Galvanized, Eloni half scrambles and half falls the remaining fifty meters, landing on her seat where the bridge butts against the wall. She starts fumbling with the 'biner holding her line to the wall belay line. Ed, clipped to a line, moves to help her—I think he has a knife in his hand. Heedless, I follow him using crampons and ax. Ed reaches Eloni.

I look up and see the sky falling.

Randi releases and leaps from almost twenty meters up on the wall, un-belayed, right at me. "Catch," she shouts.

I have time to set my crampon spikes and open my arms. She hits hard, and various pieces of her gear dig into my chest. I grab her as the boots tear free and we skitter together down the side of the bridge. My line stops us after a three-meter slide.

Ten meters from us, with a roar clearly conducted through the ice we lie against, an avalanche of clathrate pours down. There is no sign of Ed and Eloni.

Randi clips a line to my belt, rolls off, and starts to scramble back to the top of the bridge, ice dust streaming around her.

"Ed!" she shouts. "Eloni!"

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The fall increases, becoming a white wall. Randi scrambles into it. I follow and am enveloped in a stream of pulverized clathrate, and I can see nothing. It flows over me, not like sand or water, but something in between—not dense, but still exerting pressure.

I wait. My helmet is filled with the sound of my breathing.

"Ed!" Randi shouts again.

"We're alive." Ed's voice is hoarse and strained. "Trapped next to the wall. The fall created a bit of a pocket. No injuries, but it's getting somewhat cold."

In spacesuits with rebreathers and plenty of energy, we are in no danger of suffocating. But under our coveralls we wear skintight vacuum suits that depend on a surrounding vacuum for much of their thermal control and the fabric of the vacuum suits, while smart and extremely tough, is necessarily thin. Conduction of heat could quickly freeze Ed and Eloni. But, clinging to the side of the bridge with the landslide still in progress, there is nothing I can do to reach them.

"Got you on locator. Can move." That is Randi Lotati, for me. Move? How?

I roll over prone to the face of the bridge, reach forward into the flow with my hands, and find purchase. With both arms and legs, I find I can edge forward, too.

"Solid piece—here." Randi says. "Ice boulder. Think you're on other side."

"S—sounds that w—way," Ed replies.

"Line charge. My side. Push like hell when I say."

"No, Randi," Ed pleads, "too dangerous—"

"Push, damn it! Now!"

I hear the crack of the detonation.

"Randi?" I call, and claw my way toward the signals, white sand and occasional rocks still streaming by me. Somehow, though, it seems a bit easier. "Randi, Ed?"

"Wojciech, Ed. We—we're free. At—at least the rock's split. Need help with Eloni."

"I'm trying." I pant. "Where's Randi?" I am exhausted struggling against the continuing stream of material from above. I reach forward with my hand and hit flesh. Someone there. The world is gray in my helmet lamp; I can see nothing. "Ed, is that you?"

"Not me, mate. It's slackening a little. I've got some space."

The someone moans. The groan is female.

"Eloni?" I push the person in front of me again, harder.

"She's with me, Wojciech." Ed says.

"Randi?"

She grunts. "Wojciech. I'm OK. I'm just . . . stuck. Legs won't move." I feel a hand brush mine, then lock with mine. "Drag me back."

"I'll try." Trusting the precarious hand link, I sit up into the flow of clathrate mud. It tries to take me away with tremendous force, but my line holds me. Slowly I get my legs around in front of me and pull as hard as I dare. She doesn't move.

"It's no good. I'll hurt you if I pull any harder."

"Freezing's worse. Hurt me. Pull."

God knows how much force I put on her arm, but something seems to unstick, and she comes toward me, slowly at first; then something breaks

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free and we scoot back about four meters. I can see through whirls of snow here. I can see my clip still on the bridge line, see Randi strung out at the end of my arm.

"Dr. Lotati, she's out. Over here."

"What? Wojciech? Where? . . . There, I have you! I'll be right over."

He is there in a moment. "Had you on the other side of the Bridge for a moment—propagation freak, I think. Randi, will you be all right for a few minutes?"

"Hurts like hell, Dad, but yes. Thanks, Wojciech."

Dr. Lotati gives her a pat and plunges into the remains of the ice fall. Minutes later, he and Ed emerge, carrying Eloni between them. "Mike, Karen, this is Emilio," he says. "We're all out of the avalanche. I don't know in what shape yet, but we're all out."

"Roger. We suggest all of you rest a bit until this plays itself out."

"Mike . . ." He pauses, catching his breath. "We'll consider that."

There are several rueful chuckles, and we spend the next five minutes or so, watching the river of white dust slowly come to a halt.

Finally the ice fall abates entirely and we take stock. Randi reports a severe sprain in her right shoulder. Ed is recovering from hypothermia and is severely bruised as well. Eloni is better, physically, but appears to be in some kind of psychological shock. The rest of us have minor bruises.

The side of the crevasse looks like a giant took a huge, semicircular bite out of it. Karen and Mark wave at us from an edge that is now at least fifty meters back from where it was. We lost two long lines, buried in the debris. The avalanche has buried half the bridge and I worry that it could start again at any time and bury us along with the other half. I try to do some mental calculations on how long it would take a suborbital hopper to get here and pull us out.

"I think we are here for a while," Dr. Lotati says, "at least until we're all up to climbing out again. We might overnight on the bridge." If he's worried about the avalanche restarting, he isn't saying so.

"We'll need to revise the schedule a bit," Ed adds. "Another five kilometers per day would do it, I should think. Now, how do we get the gear down here?"

"Toboggan the big tent down to us," Randi says. "Meantime, collect data."

I stare at Randi, stupefied.

"Are you OK, Eloni?" I ask, mainly out of concern but perhaps with a secondary agenda of reminding people of something.

Eloni raises her head and looks around in wonder. If she expects a chewing out, it seems she is in the wrong group. I lay a hand very gently on her shoulder, and, as if I touched some kind of hidden button, she leans into me and lets out a very long sigh, which I hear clearly where my helmet touches her. Randi is looking right at us, but in the glare of our headlights, her face is unreadable. Warning bells ring in my head.

"My mistake, Eloni," Ed says, "pressuring you like that for something that's not automatic. You needed to think it through, and with me talking

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at you like that, you couldn't. My mistake."

"Eloni," Dr. Lotati asks, "Can you help Juanita get her samples tomorrow?"

Eloni takes a breath and slips away from me. "I—I can do that." A smile of relief creases the young woman's features.

"That a way!"

"Randi?" I ask, dumbfounded. "Your arm?"

"I'll live. Still go for the bottom, Juanita?"

"There may be a pond of liquid nitrogen trifluoride down there—it's unprecedented."

"Ed?"

He looks down, then at the crevasse sides. "Why don't I help Randi with the camp and prepare for climbing out of here?"

Apparently, we *will* sleep here—under the sword of Damocles.

"Wojciech?" Dr. Lotati asks.

I am at a loss for words. I am more tired and sore than I have ever been. How much more tired and sore can I be before I am a danger, I wonder? Everyone has been pummeled and challenged. But these people, these comrades of mine, will not admit disaster. They will press on. It is a collective decision—a spontaneous informal vote of voices that is already a majority. Voicing misgivings on my part would do no good at all, and my fate is tied to theirs. But I wonder that such things can still be in this age of robots. May the ghosts of Byrd, Amundsen, Lewis and Clark, and Bering fill my mind with whatever it is that gets one through. I came here to prove myself worthy and now the question is upon me. I look at the crevasse sides and down into its deep.

"Three climbers would be best." Dr. Lotati says.

"I'm . . . I can go with a little rest."

Dr. Lotati nods. "We can all use some. It's only 1100. We'll set up on the bridge. Mike and Karen, we'll take the big tent—you can probably slide it down on ropes."

This only takes a few minutes. We anchor the large vacuum tent to the bridge. It fits with about a meter to spare in width—with the door toward the intact wall. Room in the tent is limited. It was meant to sleep four and it is crowded with six of us. Our body odors again mingle in a forgettable stew of smells, and the drop curtain for its tiny commode is woefully inadequate for privacy. But we are relieved and happy—we have been through a memorable adventure and nobody has gotten killed.

Ed is quiet, eats quickly, and is asleep in his sack, fully clothed, in minutes. He says nothing. We will take a very real risk shortly, far, far, from help—for the sake of samples that could easily be gathered by robots a month from now.

As a certified—and some might say certifiable—poet, suicidal undertakings are perhaps in my nature. But the milieu of the Gentleman Adventurer requires that one return from the adventure to recount it. While Ed was gallant in the crisis, the closeness of his brush with death might only now be sinking into him. I, with far less experience, accepted a challenge he did not—does he resent this? No, I tell

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myself, he is just exhausted.

I have to make myself eat—I'm hungry, but more tired. A warm sleep-sack never felt so good, I realize. It seems I have barely closed my eyes when Dr. Lotati is gently rocking me awake.

"It's 1400," he says. "Time to go."

The trip to the bottom of the crevasse is a straightforward rappel. With Randi resting her arm, Eloni and I head for the bottom with Juanita in the lead.

"This could be Calorian clathrate—proof that Chao Meng Fu is older."

"But doesn't its flatness mean it's young?" I ask. Old surfaces are heavily cratered.

"Watch for a hollow to your left. No, the surface is young due to deposition—the crater itself is ancient. I'd guess we're about 3.8 billion years down, below the original crater floor. The walls are shock-fractured rock, not exposed sediment layers. No strata—" a swing of her ax tears a rough section of about a square meter from the wall "—underneath."

"Look, more signs of erosion," she adds later.

"Erosion?" The wall is a rough breccia, a compressed clathrate and gravel mixture. The larger stones are sharp, not rounded.

"There is evidence of atmosphere all around us—you can see icicles in the hollows, and a cold glistening wetness on the walls."

I turn off my radio. "Can you hear me?" I shout.

There is no answer—the vapor is still too thin, even at the bottom, to conduct sound.

We hang from the wall and gaze into the utterly still pool of nitrogen trifluoride in the circles of our helmet lamps below us. Unable to resist the temptation, I reach into one of Mercury's nostrils and break off an icicle and toss it into the pool. It ripples like oily water.

"Wojciech," Eloni says in a mildly scolding voice, "have some respect! That pool has been built up, molecule by molecule, probably over billions of years."

"How?" Juanita asks, gently. "Even if the crater is that old, the crevasse isn't."

Eloni is silent, then says. "Oh, of course. But where does it come from then?"

"The pool is a mystery, for now," Juanita says. "Perhaps some comet with an unusual concentration of fluorine ices struck not too long ago. Or something else." She laughs. "Fortunately, not all mysteries can be solved now. We would run out of things to do!"

I envision tentacles reaching out of that deep to pluck us from the crevasse wall. "Could something have evolved to base its blood on that, the way we use seawater?"

"Not my field," Juanita answers. "But let's take a sample."

She is closest, and deftly dips a sample capsule into the liquid. Nothing emerges to bite her hand off—so much for that fantasy. I might not have had the nerve. Then I have a moment of insight; to do this requires the right balance of imagination and nerve.

"I do not think," Eloni offers, "that there would be enough energy for

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life. If there were, the liquid would boil away. Hydrocarbons at these temperatures would be frozen solid, so what could one use to build life molecules? How could anything that would work at these temperatures get here without being destroyed by the Sun first? Still, it is an interesting thought, Wojciech."

"If the crack could go down a hundred kilometers or so," Juanita remarks, "it would be warm enough to evaporate everything, possibly warm enough to walk around with the right atmosphere. But Mercury would close a crack that deep; its crust is surprisingly thin, even now. This is not Mars."

She sounds like my fifth-year teacher back in Krakow. I suddenly feel far, far over my head. These people understand where they are and what they are doing: it holds no terror for them, no fear of sticking a hand where it might not come back. But for me, my overripe literary imagination haunts my mind like the tale of the bogeyman that kept me out of grandfather's basement until I was seven. I am not comfortable here—but, I tell myself, I will enjoy having been here *more* when, and if—always if—we get back.

"It's time to go back," Juanita says, her vials filled. "Climbing."

"Climbing," we all say.

"Belay on," Dr. Lotati says, from far above us.

The climb back up to the bridge is slow. Once we hit the layered material, we stop to take half-meter cores, drilled slantwise, at those layers which Juanita estimates to have been laid down during the great events of the inner Solar System: layers that may contain glass beads from the Imbrium impact on Luna, Caloris here, Hellas on Mars, and, just possibly, a few grains with the right isotope ratios to be from the K-T impact on Earth. If we find these, we can bring the geological history of the planets together. If, the paradigm goes, we understand better why the Solar System is the way it is, we will understand better why we are the way we are—the forces that have shaped our evolution and those of other sentient races. But we won't know if the samples contain what we suspect for many months, by which time we will have scattered to the nether ends of the Solar System.

We are tired and bruises remind us of yesterday's avalanche with each bump, but there is a sense of elation about us. We are the first people to see a pool of liquid on an alien planet in its natural state. And no machine saw it first.

When we arrive back at the ice bridge, Juanita sees me staring nervously at the slide.

"I've calculated the slope and the coefficient of friction, Wojciech—I think it's fully relaxed. It may stay that way for a billion years."

"Now you tell me!" But would the trip have been as thrilling if she had? "What caused it to go in the first place?"

"Our weight, I think, plus an accumulation of stresses. I'm beginning to think the crevasse is fairly young—otherwise a meteor impact would have caused the slump before we did."

"There could be more than physical

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tension," Eloni says. "Near the surface, over many years, radiation will cause chemical changes and produce unstable molecules in crystalline ice. A physical shock, such as an ax, might release these energies."

"Possibly," Juanita says.

I look down at the ice bridge under me. If the crevasse is fairly recent, this would be even more recent—and not, I hope, have had time to accumulate radiation "energies."

We are physically tired but the midday nap and the feeling of accomplishment leave us too hyper to sleep immediately. After rations, I suggest the idea that had led me to join their expedition in the first place.

"Randi?" I ask. "Dr. Lotati?"

They turn their heads to me.

"Are you aware of the theories of a Dr. Nikhil Ray?"

Dr. Lotati purses his lips as if he had something to say, then thought better of it.

Juanita answers. "He tries to explain the low density of Miranda and some other outer satellites, by making them a sponge of caverns. It is an innovative idea, but, I'm afraid, not well accepted."

Dr. Lotati grunts. "I've met the man. His theories are unorthodox and he has this infuriatingly superior manner about him. . . . Well, we'll know soon enough anyway. The IPA is finally getting around to dropping sonography stations on the major Uranian satellites."

As "free" robot-produced resources grew exponentially, so did the Interplanetary Association's influence on who goes where and does what. The IPA, whose main members are the United Nations of Earth, the Mars Council, and the Cislunar Republic, responds, in large measure, to politicians. They in turn respond to the media and the public—I am counting on this.

"I was," I venture, "thinking that it might be time to visit Miranda—and that, with the coincidence in their names, Randi might be the one to do it. It would certainly be an interesting angle. Especially if Dr. Ray could be persuaded to come."

Dr. Lotati frowns. "That would be rather commercial, wouldn't it?" Ed contributes with a wink in my direction. He is not taking this too seriously.

"Finish school," Randi says, "do some low *g* work in the asteroids, Saturn, then maybe." She grins at me. "My world. Caves?"

"There are certainly caves there," Juanita says with a grin, "but if they are big ones, you might be sorry about taking Nikhil. He's already insufferable with the issue in doubt. God help us if he's right!"

Dr. Lotati and Ed laugh heartily. Randi shrugs, and a flicker of pain crosses her face at the gesture. The shoulder hurts more than she wants us to know, I suspect.

"You can make too much of that," Ed says. "He's not a monster, Juanita. He can be very much the gentleman, and his conversation is always interesting. I sometimes wonder if the personality conflicts don't have more to do with his peer review problems than the merits of his work."

Dr. Lotati turns and tugs on his beard. "Uranus is the frontier," he finally says. "There's only one small inhabited scientific station in the

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Uranus system, in its outer satellite, Mustardseed. Within the Uranian magnetosphere, radiation is a concern." He stares briefly at me, then Randi. "Also, I don't want to associate the Society with Ray's claims just yet. Let's see what happens with the seismic study. And let's see how well Wojciech's presentation of this expedition is received."

I glance at Randi. She stares back at me, intently, and the ghost of a smile crosses her face as she wrinkles her nose.

"I could use a shower," I say—humorously. There will be no showers for several days yet.

But Randi hands me a silver foil wrapper. Her nose has decided that it's bath time—understandable in view of our exertions. The foil contains a light towelette soaked in a cleaning solution that does not have to be rinsed. She offers them to the others, removes her coveralls, and then releases the seam of her vacuum suit. Her father turns his back to us and, facing the wall of the tent, does the same. Eloni also turns to the wall of the tent. Ed watches Randi, and they exchange a brief smile.

We are a cross section of the Solar System, and a cross section of attitudes about our bodies. I still feel a slight twinge, as if in nostalgia for an old cultural taboo, but the observer of people in me rejoices the passing of taboos. Ed, surprisingly, seems the one uncomfortable with communal bathing.

Juanita, whose family left Earth a century ago, is already sponging, oblivious to anything else. She is a well-endowed woman in excellent condition, as is everyone on this kind of endeavor. Her hair, unbound, hangs to her shoulders. It is almost all white and makes her skin look darker than it is in contrast. Her only other concessions to her fifty standard years are a slight gut and a bit of looseness on her neck and under her arms.

Randi is still watching Ed watch her, as if she enjoys it. She is a rangy young woman of jet-black hair and well defined, though not exaggerated muscles. Her female features seem like the afterthoughts of a god who in making an athlete decided at the last minute to make a woman, too. There is an intriguing hardness about the rest of her, including an untouched scar on her side. But her face, her smile, and her manner are womanly.

Embarrassed at myself for staring, I turn around like Dr. Lotati and finish undressing—applying the cleaning cloth to my body. But I love women too much to resist another look. When I do, both Eloni and Juanita are looking at me. Our eyes meet, we smile and I relax. My feelings as they watch me bathe are hard to describe—would it make sense to say that I felt first forgiven? I feel something of a sense of camaraderie.

Then Eloni reaches with both hands and turns me to the side of the tent. Its drum-tight bulge instantly reminds me of the vacuum, just beyond that millimeter of tough, impervious fabric.

I feel a damp cloth on my back, up and down, hitting every needful spot. When she is done, I return the favor. She sighs just on the edge of audibility. Almost like a purr.

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I feel suddenly very good, and useful—should poetry and nature writing fail me completely, I could do this for a living. Well, maybe.

Dr. Lotati turns to crawl into his sleeping bag, and I accidentally get a brief glimpse of injuries he has chosen not to show the rest of us. Gunshot wounds? Before he can seal the side, Juanita touches his shoulder and crawls in with him.

Eloni turns from the wall then and sees Randi and me, not yet in our sleeping bags. She looks down, then looks up again, then crawls into her sleeping bag. I can't read the expression on her face.

I get into my bag, pull my suit and helmet in with me, and seal the hood behind me. Its flaps will close and hold pressure if there is an accident while I sleep.

"Lights off," Randi says, and the tent complies. It is utterly, totally dark. There is movement. As my eyes adapt, I glance in her direction, but her sleeping bag is empty. She is probably not sleeping with Eloni, which leaves Ed. I feel a twinge of jealousy, though I know Ed has known the Lotatis for many years, and gone on several expeditions with them.

The exhaustion of this day does not permit sexual regrets, however. It seems like only a moment, and then I awake to light, discussions about the ascent, and the smell of freshly opened breakfast bars. The discussion is between Ed and Emilio, and it concerns who is to go up the wall with Randi, to set the ropes for the rest of us.

"We need to make time," Dr. Lotati says.

"All the more reason for you to go with Randi. You're a team."

"Thank you, friend, but I am sixty-two years old and you are thirty-eight. You and Randi climb well together." There is a slight hint of humor in Emilio's voice to suggest to my perhaps oversensitive mind that he knows they do more than climb well together.

"It's only a kilometer, mate. You're as good as ever."

"I'll second that," Juanita says.

Dr. Lotati smiles and shakes his head. "The group comes first."

Randi embraces her father, wordlessly, but I can see her eyes glisten. Then Dr. Lotati reaches over to Ed and they grasp hands.

Something has passed, I realize, and who am I to witness such a passing? More than ever, I feel an ambitious interloper. I look over at Eloni. She is looking at me. Wistfully? I smile back.

We pack quickly and efficiently, filling the soft pressure packs first with the things that can stand vacuum, then the hard ones. When the tent is bare, the last pack is sealed and we take it down to a tenth of an atmosphere. We check each other's seals and fit. Randi frowns at mine, and has me depressurize to readjust my fit. If the pressure were much lower, I think, my blood would boil. We normally breathe a fifty-fifty oxygen-nitrogen mix at four-tenths atmosphere, so I still have a quarter of Earth normal oxygen partial pressure. I try not to get excited.

Randi treats this like an everyday event. She tugs, pulls, and smooths all

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my joint areas. She is utterly clinical about this, but happens to glance up with a wink when she adjusts my leg seams. "Its all in the family," her look seems to say.

I find myself slipping as if to an event horizon. Do I want to befriend this woman to pursue fame and fortune on her distant namesake moon, or has my idea for an expedition to the moon become an excuse to be near the woman? I suddenly realize that I am very, very taken by her.

She reseals my suit and I tell it to bring its pressure up again. She has indeed worked wonders, and I am much more comfortable than I was the day before. She apparently likes what she sees, grins, and squeezes my arm, then turns to the business at hand.

The tent finishes taking itself down to near vacuum. When the sides are noticeably softer, we open the main seal, and the tent ripples as the remaining millibar or so of air escapes. We turn our helmet lights on and emerge into the crevasse again.

The wall is suddenly lit with floodlights—Mike and Karen have seen us emerge. It is one kilometer of gray-banded dirty clathrate, vertical, except for the parts that are more than vertical.

Randi leads; if she falls, she is less weight on the bolts and pitons that hold our ropes.

"This stuff is like soft sandstone," Ed says. "I can almost push a piton in by hand, here and there."

"Use more." Randi says. "Angle down."

"OK." He is silent for a while. "There. I suggest we do this before I lose my nerve. Belay on."

"Climbing," Randi answers. They proceed upward carefully but steadily, taking turns.

I happen to be looking up when it happens. Randi is climbing when her foothold crumbles. She grabs for a line, says "Damn!" then, "Falling." Her effort to grab has pushed her out from the wall, and when the rope goes taut, one of the pitons pops out of the wall with a shower of dust and ice. After a brief hesitation, the other two follow, and Ed yells, "Slack!"

Desperately, Randi tries to slow her fall by digging her hands and crampons into the wall beside her, throwing up a wake of dust. The smoothness of the wall helps; it is not completely vertical, and there are no bumps to throw her out.

The next set of pitons catches her rope, and for half a second it looks like it might hold. But before she comes to a complete halt, they pull out too and she starts to slide down again. Now, only Ed's own precarious hold on the wall stands between them and a five hundred-meter fall. He is furiously trying to hammer in more pitons, but there is little rope left between him and Randi.

They need another secure line. Why, with six other more experienced explorers present, I am the one to think of something is a mystery. Perhaps it has something to do with creativity, or with not having a mind full of the knowledge of things that wouldn't work.

"Mike, Wojciech. Can you fire a rocket line right into the wall above

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them? It ought to penetrate that stuff and anchor itself. "

He doesn't take time to answer me. There is a flash from overhead and an impact ten meters above Ed. The line it carries is much thinner than climbing rope, but drapes down beside them quickly in the vacuum. It continues to play out, draping all the way down to our little camp.

The line between Randi and Ed snaps tight, and his foot and arm come free in a shower of ice. He should hit the release, I think. Better one death than two, but he tries to hold on to the wall. He doesn't dare let go and reach for the new, untested line, hanging less than a meter away.

It almost works. Randi, caught short, manages to reach her ax and digs into the wall like a desperate fly. Working with her right hand, she sets one piton and then another, hammering them in with her fist.

Above her, the rest of the ice holding Ed begins to give way as he tries to regain his handhold. "Can't hold, falling!" He flails for the new line as he starts to slip, but it is out of reach.

They, would, I think, be dead on Earth—but Mercury gravity is more forgiving. Working as Ed slides, Randi reaches the new line and yanks hard on it. She yanks hard again—it must not have been firmly set. Another hard pull and she seems satisfied. Ed slides down beside her in a plume of dust and ice, barely in contact with the wall.

Quickly Randi connects the new line to the line that still connects them, slack now, and loops it around the piton she has just set. "Protection in!"

Thirty meters below her, Ed bounces as the line pulls taut and pops the piton out of the wall in another shower of debris. Ed's weight pulls Randi free of her holds as well.

They both slide another ten meters, but now the slack in the line from the rocket has been taken up. They slide some more as it stretches, then, finally, stop. All told, Randi has fallen about a hundred meters and Ed perhaps fifty.

"Jupiter!" Karen, on the crevasse rim, exclaims. "Randi, Ed, set yourselves if you can. I can see the rocket: it's wedged itself vertically in the hole it made when it hit the wall, only about ten centimeters from the face. Try to hold tight while we think of something."

"OK," Ed says. "But don't take too long. I think I'm about at the end of my rope about this."

The laughter, fueled by relief, is perhaps a little too loud for the quality of the pun. Ed quickly starts hammering in additional protection. Randi, however, is simply hanging passively in her harness.

"Randi?" Mike calls.

"Injured. Both arms." Her voice attempts calm, but I can hear the pain in it.

"Can you climb?" Mike asks.

Randi tries to lift an arm up to her rope and gasps. "Not now."

"Descending," Ed says. "I'd like another belay if you can think of something."

What we think of is setting our remaining line rocket for maximum range and steering it about six meters under the far edge of the crevasse. It

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slams in hard, burying itself too far in for Karen to see. "Ice," Mike says, instantly, as a patch of icy regolith loosened by the rocket impact snows down left of the climbers. The upper layers, as we know, are softer. They pull the line from the far edge until it sets hard—ten kilonewtons tension, Mike estimates. Then they let the line drape down to us, and we walk it over to where Ed can reach it.

He connects the lines, and continues down.

Randi tries to descend. We hear the slightest hint of a cry of pain over the radio, then a loud "Damn! Dad, I can't lift my hands over my shoulders. Both shoulders shot."

"That's all right, Randi, I'm coming." Dr. Lotati turns and looks at me. "Come on, Wojciech. I want your head on that wall."

Juanita gives me a pat on the rear, and surprisingly, Eloni gives me a silent hug. Inside her visor, her dark eyes are glistening. I think of how frightened the Kenyan student must be, but she has just contributed in the only way she could think of.

"Thanks, team," I say, and squeeze her hand.

I clip my ascent ratchet on and start climbing. There are no problems and we reach Randi and Ed in half an hour.

Randi is calm. "Right arm. Won't go above shoulder. Maybe dislocated. Left arm works, sort of. But hurts too much. Might faint. OK as long as I keep my hands down."

"I'll take you down, papoose-style," Ed offers. "Then we'll ride the elevator up."

Dr. Lotati touches Randi. "OK?"

"I'll make it, Dad."

"Good, Wojciech and I will go up then, and set the anchor," Dr. Lotati decides. His voice crackles with leadership and confidence. I smile. Everyone, including him, has forgotten about his age. It won't be obvious on this climb; if anything, I will slow *him* down.

We replace Ed's backpack with Randi, tying her to his shoulder harness, and help guide them down. When they are safe below, Dr. Lotati nods to me, and says "We have to consider everything we put into this surface to be hazardous, no?"

I nod. We are leaning out from a wall almost half a kilometer above a bridge about half a kilometer above a pool of cryogenic nitrogen trifluoride, talking about how the various things that hold our ropes to said wall may give way at any time.

"OK. We use four pitons, or bolts, or a combination, on each belay, and arrange the ropes like so." He demonstrates, creating what looks at first glance to be a cat's cradle of ropes between carabiners and pitons. "This equalizes forces among the pitons and minimizes the shock if one lets go."

It takes me a couple of tries to get it right. He finally pats me on the shoulder, and without further ado says "climbing."

"On belay," I answer, wondering about people who seem to come alive only when staring death in the face. He ascends deliberately, and deceptively fast.

Actually, I keep up, but exhaust myself in the process. Dr. Lotati is only a centimeter or two taller than his daughter, and hardly much heavier.

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He is wiry strong; occasional rest stops are the only concession he makes to age—and I need them more than he does. We stop where the second line-bearing rocket buried itself in the fragile clathrate, six meters below the crater floor. The ledge is overhung by about a meter, more where the rocket impact dislodged a large hunk of wall.

"Can you stand a short fall?" he asks me. "I think we'll need several tries to get around that edge." I've never fallen on a belay line before. I want to impress Emilio; my Mirandas, moon and woman, are at stake. But the idea of trying to scramble almost upside down and free-falling six to ten meters, with only a questionable anchor to stop me if I slip, scares the crap out me. If there were any other way . . .

"Wojciech?"

"Yes." Then, perhaps because my mind works best in an emergency, or under a deadline, the idea comes to me. "Dr. Lotati—this is fairly soft stuff. You don't suppose we could just tunnel through it, up to the surface?"

He looks down at me. "Perhaps! I wouldn't consider desecrating an Earth climb like that, but I think we will be forgiven here. I knew your head would be good for something!" Then he takes an ax from his belt and swings it into the ice overhead. A good sized hunk falls and shatters into tiny chips on my helmet.

"Ice!" He looks at his handiwork, says, *"Sì,"* and swings again, and again, cutting a notch more than a tunnel as it turns out. We are through and up to the crater floor in less than an hour.

There is a round of cheers when we say, "On top!" Mike and Karen wave from the other side of the crevasse—only a hundred meters away. It has taken us two days to go that hundred meters.

I help set the next set of anchors a hundred meters back from the edge, in firm regolith. The rest is ropes, ascenders and pulleys. Mike and Karen send the remaining gear, and themselves, across in an ersatz tram, and help us hoist the rest of the party. Juanita is the last one to emerge from the crevasse and we all cheer, intoxicated with our close call and our final victory. By the time everything is up or over, we have been awake for thirty hours. Dr. Lotati decides to set up camp immediately.

We have four two-person tents in addition to the large one. They can be independent or their entrances can be sealed to connecting ports in the large tent, forming a mini-base looking something like an inflated starfish minus an arm. That way, early risers can let others sleep.

Randi's left shoulder is bad—a possible separation—and we have at least three days' march ahead of us to our pickup point. We discuss an evacuation, but she won't hear of it. Mike and Ed both have field medical training but Mike has more practice, so he is the closest thing to a doctor we have, and he consults with Earth. It turns out that our optical scattering imager is good enough to build up a picture of the injury; Randi's humerus is not quite in its socket.

Earth recommends evacuation. Randi says no. Dr. Lotati supports

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her—we are in an age where injuries can be healed if they can be endured, but the opportunities to do something more significant than entertain oneself and collect one's automation stipend are few and far between.

Randi, Ed told me several nights ago, is Dr. Lotati's only son. I laughed and asked Ed what that made him. "The gayest man on Mercury," he answered—and threw such a convincing leer at me that it took me an unsettling second to get the joke. But the humor disguises a poignant situation—a young woman trying to be, for her father, the son he could never have. How much was from her nature, how much was from her love? Or was there a difference? And what of her mother? Randi's mother was never mentioned by anyone, and the only public biographical info was that Emilio had divorced her when Randi was six and never married again.

Following instructions from the doctors on Earth, Mike resets the shoulder. It takes him two tries. Randi shuts her eyes and gasps—that is all. Then it is in. Painkillers, anti-inflammatory drugs, and reconstructive stimulants we have—she will be sore, but as good as new in a few months. Climbing is out, but she can walk the rest of the way.

Ed and Randi retire together, her arm immobilized to her body with tape.

Juanita decides to sleep with Emilio. Mike and Karen are a given.

Eloni is looking at me with dark pools of eyes and what could be a hopeful smile on her face. I look at the shy graduate student who had given me a hug to send me up a treacherous wall that had just come within the width of an idea of killing two people. I shrug and reach a hand out to her and she comes and sits by me with the widest grin on her face I have ever seen.

"You wish I were Randi, don't you?" Eloni asks me.

"That's not your fault."

Her smile fades. "I almost got us all killed by being too slow. That was my fault."

There are times when sympathy can do things lust cannot. I have my arms around her in a second. "No one blames you. You're part of us, now. Time to enjoy it."

She kind of melts into me and gently pushes me down onto my back on my sleepsack. She has a low, incredibly sexy voice. "That is about as much as I can enjoy. I hope I do not disappoint you."

Tired as I am, I'm relieved, and confused. "Eloni, I write about the male and female thing, more from reading than experience, I'm afraid. I may sigh, but disappointment would be putting things a bit strong. But I'm curious. Do you believe in abstinence, and if so, can you tell me why?"

No contraception, I speculate? In this day, I find that hard to believe—but she is studying at Jovis Tholis on Mars, I remind myself, in the middle of the New Reformation.

A certain hardness comes over her face. "You want to know? I spoke literal truth. Abstinence has nothing to do with it. I was mutilated so I cannot enjoy what most women can enjoy. So I hike across glaciers and climb

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mountains instead," she smiles wryly. "That is how I get high. Try to understand. I am not Kenyan by birth. Kenya is a civilized nation."

I have it then. Female circumcision. Back on Earth, the villages all have nice premanufactured houses, with bathrooms, electricity, diagnostic comm ports, and regular food deliveries. But here and there, otherwise gentle people protect primitive cultures from "western interference," and so we still permit this to be done to children.

"How old were you?"

"Ten. They were very thorough. But in a few years, doctors will be able to fix it, I think. Regenerate the tissue that was taken from me. That's a spin-off from the interstellar project. They needed to solve tissue regeneration to do cold sleep reliably. For now, I must enjoy giving and being enjoyed while I fantasize what it might really be like."

What can one say? I take her hand and she squeezes it.

"Oh, yes." Her voice is low and throaty. "They mutilated me, they tried to keep me barefoot and stupid to carry on their primitive culture. They even tried to keep me from school. But they could not shut off my mind. And here I am, yes, here I am where they thought I could never go doing what they thought to keep from me forever. So I am a space person now, part of another tribe."

Eloni and I are both, I realize, refugees from cultures that do not want who we are. Hers a primitive one, mine too sophisticated to see itself. I only want to hold her, smother her hurt, and bring a smile to her face. I try to kiss her.

She holds me off. "Someday I have to go back there and try to change what the people do to each other there. I cannot be a space person forever. Do you understand?" She buries her face in my shoulder. "For now. Just for now."

I understand. This is for now—and whatever our feelings for each other now, our destinies lie in different directions. I nod and she is in my arms. Our lips touch again and the future vanishes. "What do you do want me to do?" I ask.

In answer, she releases the seal of my tight suit.

We remove each other's remaining clothes and slip into my sleep sack. She wriggles against me and we do kiss, and our hands do stroke and caress, and begin to defy the cold dead gray cruelty outside our bubble with yet another act of life.

But there really isn't very much room and we are both very tired. So, in each other's arms, we fall asleep, content with a mostly symbolic defiance.

The remaining walk toward the center of Chao Meng Fu is two by two, the time filled mostly with conversations that share what we are and what we know, but sometimes with those comfortable silences in which your mind digests what you have learned, playing this way and that with it. There are more crevasses to cross, but we do so expeditiously.

During one of these crossings, I say, "On belay, Dr. Lotati."

"Climbing. Wojciech, call me Emilio, it's quicker."

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A small thing, but it suggests to me a future more interesting than correcting undergraduate papers.

Juanita suggests we share a piece of music for our final approach to the central depot. It is by a twentieth-century composer named Alan Hovhaness, a symphony called "City of Light." She says it is his symphony number twenty-two.

"Twenty-two?" I ask. "Did I hear you right? I know Haydn wrote over a hundred, but that was when they were short and highly formatted. Beethoven wrote only nine. Tchaikovsky, six. I thought they'd pretty much stopped doing symphonies by the twenty-first century."

Juanita laughed. "We geologists call Hovhaness our patron composer because he actually wrote a symphony about a volcano—and that was number *fifty*. By the mid-twenty-first century, they were calling him 'the American Haydn.' Now let's just listen."

As we approach the brilliant peaks of the Chao Meng Fu central crown—great massive round Sun-gilded domes that speak of power and eternity—I am incapable of understanding why I once thought of this expedition as a stunt. I feel like a piece of steel, bent, hammered, bent and hammered again in the fire with greater strength and balance than I have ever known before.

It is a feeling I want to have again, if I must pursue it to the ends of the Solar System. Perhaps I am not in a class with Ed Blake and perhaps any fantasies I had of a match with Randi must remain fantasies, but I have found in my own backyard a delicate and precious union with Eloni and a friend and colleague in Juanita. And I think I have succeeded in my main objective—I have, I think, the friendship and respect of the people who could bring me out to the frontier which calls my spirit.

As I walk I feel the voices of a more broad-shouldered century calling me; Stanley, Peary, Scott, Teddy Roosevelt, and among poets, of course, Kipling. As I trudge, I amuse myself with a doggerel: Perhaps those prudent people—

Who never risk the pit,
Also never know the joy
Of coming out of it.

Not prize material, perhaps, but sums my experience, and in my present state of deranged ecstasy, I am no critic!

And if my words fail you—as they fail many others of highly educated tastes—then listen to the finale of Hovhaness' symphony. For if you cannot understand after hearing *that,* you have left the human race. What I learned, in the crossing of Chao Meng Fu, was that such things still can be, in any age, for anyone who will do them. ■

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Mark S. Lesney

BIOLOGY AT THE EXTREMES

For Terraforming and Beyond

Too hot. Too cold. Pressure too high. Too little air. Lung-searing atmospheres of methane or ammonia gas. Sulfurous waters and toxic pools of boiling mud. Radioactive wastes and heavy-metal-poisoned lands. These are the inhospitable worlds of alien biology which demand terraforming before life from Earth can find a foothold and survive.

Or perhaps not. For these are also the heights and depths and corners of our own blue and "friendly" planet. And in these places life, Terran life, survives and flourishes. The biology of these hardy organisms is a unique resource of profound interest. Their DNA is the stuff from which the terraforming creatures of the future may be created, not only to claim and transform alien planets, but through the process known as "bioremediation" to claim and transform damaged and inhospitable habitats of our own.

The current bioremediation engineers might be considered the first pioneers in the development of professional terraforming. Their use of biological organisms, both natural and genetically designed, coupled to the studies of biologists who examine life in its extremes have long-term potential for helping human life adapt to other planets. This is an idea made even more plausible and exciting by the increasing discovery of what appear to be Jupiter-sized worlds orbiting other solar systems, and the prediction that Earth-sized worlds may be discovered within just a few more years, orbiting around Sun-like stars (Schilling, 1996).

Ultimately, knowledge of the limits of life upon our own world at its harshest gives us hope and understanding of the full range of possible alien worlds on which life might have a foothold. In discovering these strange and exotic inhabitants of our own most terrible terrestrial climes, modern scientists have come to realize that nature may be less constrained than the imagination of past biologists had allowed. New knowledge of how adaptable life here on Earth can be is one of the main reasons that scientists can conclude that at least one of the Jovian moons, Europa, may have con-

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ditions amenable to the development, or at least the survival, of such life (Cowen, 1996; Sawyer, 1997). And hopes have been stirred as well by the evidence of putative ancient life on Mars, found in meteorite fragments here on Earth (Kerr, 1996).

What are these Earth species and what aspects of their biology, their genes, make it possible for them to flourish in the most "alien" environments of our otherwise hospitable world? They are bats that survive in toxic ammonia atmospheres. They are the worms and bugs and bacteria, fish and flowers and fungi that survive extremes of pressure, temperature and poisonous environments—former curiosities that have now become the essential study of scientific exploration into the nature and limits of the possibilities of life. These are some of the truest and most extreme forms of valuable genetic diversity on the planet.

Some of these creatures are thought by some scientists to be throwbacks to, or survivors of, the primeval evolution of life. They survive in boiling saltwater pools or without oxygen, exposed to toxic compounds most other beings could not withstand, not because they have marvelous new adaptations, but rather because they retain or have re-invented those very traits that once allowed life to first evolve, survive, and flourish (and to ultimately change) in the hell-hole that was Earth in the dawn of evolutionary time. Figure 1 shows some of the harsh locations in which the various extremophiles may be found today.

Modern theories of life's progress through the geologic ages presume that Earth itself was "terraformed" by these prior generations of life—changed from alien inhospitability to the relatively friendly place it is today for creatures of our own limited tolerance to extremes. What nature did haphazardly, design might speed up and improve. Bioengineers may one day use these organisms (or their descendants) to modify alien worlds as currently they are attempting to use them to remedy ecological disasters ("natural" or man-made) in the first modest starts at terraforming technology here on planet Earth.

Perhaps, in the distant future, these species might even contain (or point the way to the artificial construction of) the genes necessary to permit the most daring alterations of humankind itself. They may yield the genetic information for adapting human life to countless unknown, "unearthly" worlds where changing man to alien, rather than transforming alien to Terran, may be the chosen solution to an "ecologically friendly" human expansion through the stars. More likely, given typical human colonization patterns, such organisms, or those designed from their pattern, will provide the first wave of terraforming creatures capable of bringing the extremes of alien environments into the more parochial range acceptable to and favored by our own species.

Habitats of the Extremes (Many Ways to Die—If You Don't Know the Secret)

Too Hot

Some of the most inhospitable extremes, those that have most recently

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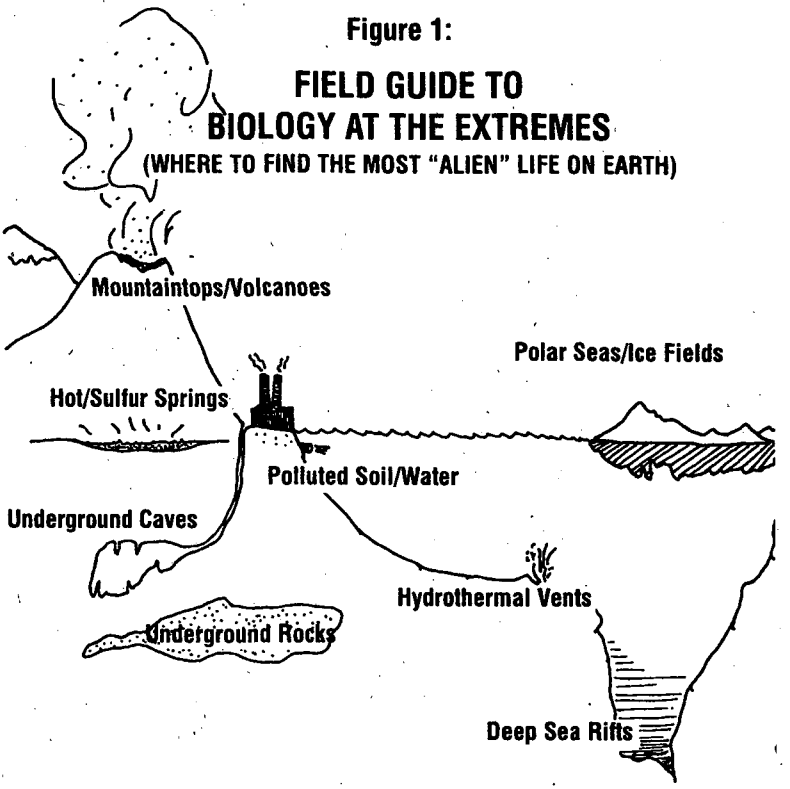
Figure 1:

FIELD GUIDE TO BIOLOGY AT THE EXTREMES

(WHERE TO FIND THE MOST "ALIEN" LIFE ON EARTH)



surprised scientists in their ability to harbor life, are the literal hell-holes of the Earth. These are places too hot for anyone to have imagined life surviving, much less thriving—boiling or near-boiling waters and muds percolating to the surface of the Earth from volcanic depths, and even at the edges of sulfurous, super-heated steam vents bursting forth in the crushing depths of the ocean. An entirely new domain of life, of microorganisms, has been discovered capable of surviving only in these extremes.

Called the Archaebacteria, they are some of the strangest creatures existing here on Earth and may indeed be the most unchanged descendants of the earliest life-forms that evolved upon our planet when its entire surface and atmosphere were as inhospitable (to "weakling" life-forms like our own) as these isolated hell-holes are now (Morell, 1996). They are providing some of the most important tools that the new biology currently utilizes. In addition, the few species that have been identified among the postulated thousands or more that presumably exist are one of our most

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powerful windows on the evolutionary past and on the potential for life evolving (or ultimately being seeded deliberately) on a host of other worlds.

One of these species, *Methanococcus jannaschii,* was isolated from a deep-sea thermal vent three kilometers below the surface of the Pacific Ocean. Scientists recently sequenced the entire genetic code of the microbe. They found that an amazing 56% of the archaebacterium's 1,738 genes were entirely new to biologists. *Methanococcus* thrives at temperatures between 48 and 94 Celsius (100 Celsius is the temperature of boiling water). It lives at pressures greater than 200 times that which we experience. It is killed by oxygen, feeding on undersea carbon dioxide, nitrogen, and hydrogen. The unrecognized genes presumably help *Methanococcus* survive in such hostile environments and, as such, are particularly exciting. They helped confirm that *Methanococcus* and its relatives legitimately belonged to a third domain of life known as archaea or archaerons. The more familiar genes of this species resemble those of the other two domains: prokaryotes (bacteria) and eukaryotes (the group that includes plants, animals, fungi, and humans).

Some scientists believe that if any earthly organisms are similar to those that might be expected on other planets with adverse conditions, the archaerons such as *Methanococcus* are "as good a candidate as you could want for something arriving on a Martian meteorites" (Morell, 1996). In fact, NASA plans to look for Martian life in areas of potentially current or former hot springs when it returns to the red planet, hopefully in the first decade of the next millennium (Jakosky, 1996).

Thermophilic (liking hot temperature) microorganisms such as *Methanococcus* have tremendous commercial as well as scientific value. They are capable of yielding heat-stable enzymes. Enzymes are proteins that perform specific chemical jobs, such as cutting molecules into specific pieces, or linking atoms together reproducibly. These processes are critically important to a wide variety of industrial processes such as food and alcohol fermentation, pollution treatment, and chemical production. Enzymes tend to work more rapidly at higher temperatures. In fact, their activity tends to double with every 10°C—which provides a tremendous commercial benefit.

Because of the way they are constructed, enzymes from thermophilic organisms tend to be extremely heat-stable. (In some sense the heat-stability of the microbe is an aggregate effect of the heat-stability of all of its component parts). At high temperatures (such as that near boiling water) most normal proteins tend to denature.

Denaturation is the term used to describe the irreversible change in proteins due to chemical or temperature damage. For example, the change in egg whites from clear gelatin to white "solid" upon frying an egg sunny-side up is an example of denaturation. In the same way that you cannot "unfry" or "unboil" an egg, you cannot unfold or repair most heat-denatured proteins. But enzymes from *Methanococcus* and

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its relatives are capable of withstanding higher temperatures than related ones from non-heat-tolerant species, and therefore are greatly in demand (Mozhaev, 1993). One of the added benefits of such high temperatures relies on the very instability of other enzymes to heat. Using a heat-stable enzyme at high temperatures can almost guarantee the uniformity of the chemical process—no unwanted "normal" enzymes or contaminating microorganisms are likely to survive to interfere.

One such enzyme obtained from a high-temperature-living microbe has been adapted and enhanced to serve one of the most sophisticated procedures in modern molecular biology research—the process called PCR (Polymerase Chain Reaction), which amplifies an infinitesimal sample of DNA to detectable levels using an enzyme capable of withstanding near-boiling temperatures which would inactivate most other such proteins. PCR technology is behind much of the forensic use of DNA for criminal identification—a minute blood, tissue, or semen sample can, with PCR amplification, provide sufficient DNA to pinpoint genetic patterns in the culprit, or to identify a victim. Amazingly enough, the microbe from which the PCR enzyme was derived was discovered in the hot springs of Yellowstone Park (Milstein, 1994).

As an added benefit, many of the extremophilic microorganisms that prove tolerant of high temperatures are also resistant to other extremes, including highly acid (pH 2.0) and highly alkaline (pH 10.1) environments. Their purified enzymes show some of the same valuable stabilities (Adams et al, 1995).

Heat tolerance is not an exclusive feature of the microbial world, either. Recently the most thermotolerant animal species yet identified has been discovered in the Saharan desert. Species of ants in the genus *Cataglyphis* have been shown to tolerate routine temperatures above 50°C. These ants accumulate heat shock proteins in their cells which help normal metabolic processes continue under otherwise inimical conditions (Gehring and Wehner, 1995).

Too Cold

Cold tolerance in both plants and animals often has a similar metabolic basis. The first way living organisms can survive cold temperatures is to prevent cells from freezing. The formation of ice crystals in cells is the chief way cold damages organisms. The growing crystals tear through membranes and cell organelles like sharp glass fragments through cellophane, killing the tissues. One way to prevent this damage is to rely on the production of natural forms of protein anti-freeze. Scientists are attempting to genetically transfer one such anti-freeze-producing gene from the ocean pout into commercial salmon (MacKenzie, 1996). Alternatively, some species have taken the route of amassing high concentrations of sugars or salts (as ice on winter steps can be melted with salt or sugar because its freezing point is abruptly lowered below that of pure water). By increasing their salt or sugar contents in a similar way, certain plants and ani-

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mals either prevent water freezing in their cells, or control the way in which the water freezes—preventing damaging crystals from forming. Siberian salamanders can survive frozen for years at temperatures down to -50°C, and frogs can survive in hibernation with up to 65% of their body water as ice (Potapov, 1993).

Some species, such as brine shrimp (Fox, 1995), have taken to "candy-coating" themselves with special sugars designed to form a protective cover, protecting proteins to the point that they undergo a process of freeze-drying in extreme cold or drought. These secreted sugars encase the individuals cells in sheaths like "rock candy," holding the proteins both covered and immobile in a glassy, desiccated state. They are then able to survive in a dormant state until the temperature rises and water can be taken up again.

Other problems caused by cold temperatures include hardening of cell membranes. The outer envelope of cells exists as a semi-liquid fat and protein membrane, like a thin coating of oil around a drop of water. Cold temperatures can begin to solidify the fats in this membrane, just as cooling melted butter causes it to congeal. This inhibits the natural functions that the semi-fluid membrane normally performs. Cold-tolerant species have evolved modified types of membrane fats that remain liquid longer. Agricultural scientists are seeking ways to modify the membrane fats of valuable food plants that are susceptible to cold, trying to change them to be like their more resistant (and often weedy and inedible) cousins. There are specific genes that control the degree of saturation of these fats and genetic engineering techniques are the most promising hope in attempts to transfer them.

Some problems exist in transferring these cold-resistance genes (or many other desirable genes for that matter) from one species to the next. Traditional plant breeders have bred cold hardiness genes from rye into wheat, but they are not active in their new genetic background. It is hoped that genetic engineering techniques, with their ability for more regulated and fine-tuned transfer, will be able to solve this problem. Such techniques have only recently become available for wheat using a "particle gun" which can "shoot" selected microscopic gene "bullets" into developing wheat embryos (see Figure 2). If this can be done, cold-tolerant wheat varieties with the kind of genes currently available could move into the Canadian prairies parallel with southern Alaska and into much of Russian Siberia, "the largest, harshest agricultural region in the world" (Moffat, 1992).

As understanding of the physiological mechanisms of the hardiness genes improves and their subtleties of regulation become known, this "terraforming" of inhospitable landscapes with economically desirable species will become possible. Since population control efforts remain a will-o'-the-wisp hope in the immediate future, increasing food production by increasing available land is an important goal for the future.

* * *

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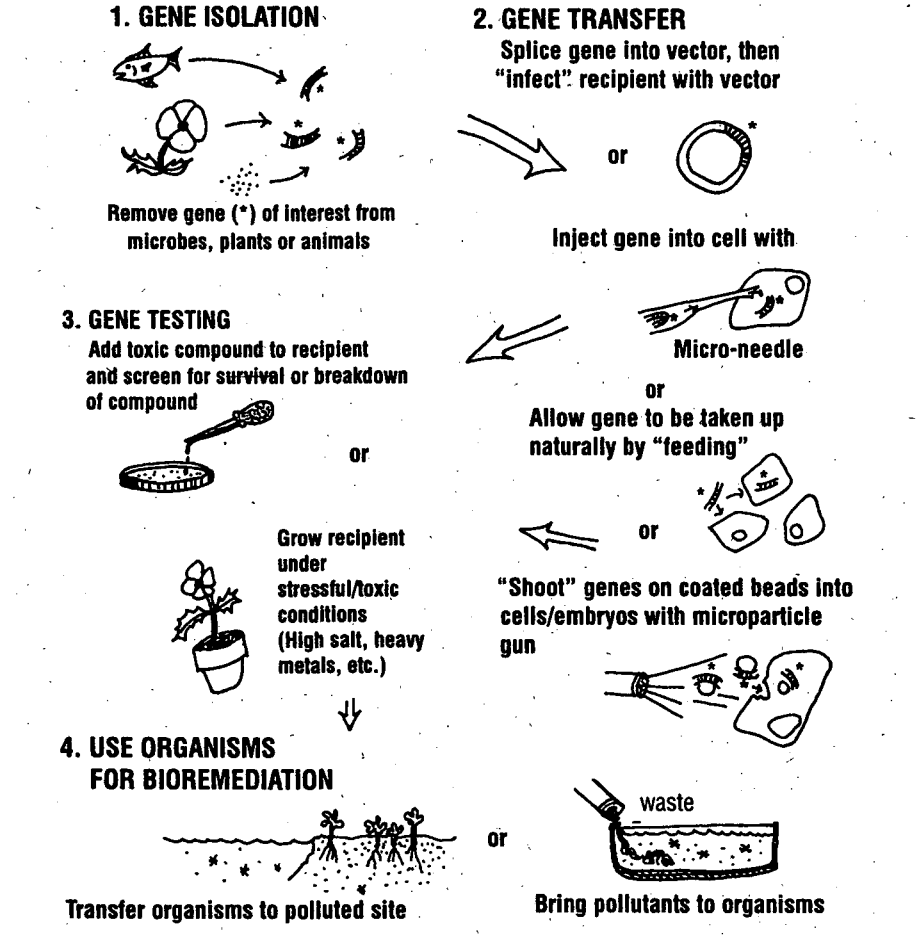
Figure 2: GENETIC ENGINEERING FOR BIOREMEDIATION


1. GENE ISOLATION
Remove gene (*) of interest from microbes, plants or animals
2. GENE TRANSFER
Splice gene into vector, then "infect" recipient with vector
or
Inject gene into cell with
Micro-needle
or
Allow gene to be taken up naturally by "feeding"
or
"Shoot" genes on coated beads into cells/embryos with microparticle gun
3. GENE TESTING
Add toxic compound to recipient and screen for survival or breakdown of compound
or
Grow recipient under stressful/toxic conditions (High salt, heavy metals, etc.)
4. USE ORGANISMS FOR BIOREMEDIATION
Transfer organisms to polluted site
or
waste
Bring pollutants to organisms

Too Little Air

Death by anoxia, lack of oxygen, is a consequence of several possible factors. There could simply be too little air of any sort due to low-pressure extremes on the tops of mountains, in the upper regions of the atmosphere (the reason cabins of planes must be pressurized), or, on an alien world such as Mars, due to insufficient gravity to hold a dense atmosphere from evaporating into space.

Alternatively, other gases, inert or toxic, could crowd out the oxygen. This is typically what happens in caves or other enclosed places where

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carbon dioxide or monoxide, nitrogen, ammonia, or other gases can build up and "crowd out" the oxygen, lowering the percentage to below tolerable limits—at least limits acceptable to humans and other unadapted species. Many animals are adapted to much lower oxygen conditions (hypoxia) than can be tolerated by man where concentrations below 6% (normal air is close to 21%) lead to death.

Certain species of bat in the genus *Myotis* show remarkable resistance to low-oxygen and even (brief) no-oxygen conditions (Britton and Kline, 1945). Other species such as *Tadarida brasiliensis*, a Mexican and South American native, can live in atmospheres not so much deficient in oxygen as contaminated by toxic gaseous waste products, most notably ammonia. The National Institutes of Occupational Safety and Health established maximal human exposure limits of 50 parts per million (ppm) of ammonia over the entirety of a 10-hr work period (National Institute for Occupational Safety and Health, 1983). Tadarida has been shown to tolerate exposures up to 100 times that amount, routinely living in caves where the ammonia level is at least 1,850 ppm. In such conditions even their fur is bleached by the fumes (Studier et al, 1967). In humans, severe lung spasms occur within a few minutes at such concentrations as ammonia dissolves into respiratory mucus, producing a caustic fluid which quickly leads to tissue erosion and death from pulmonary edema (swelling caused by serum in the lungs).

These and other deep-cave-dwelling bats also appear highly resistant to excess concentrations of other gases, both toxic (such as sulfur dioxide) and inert (such as carbon dioxide), which would prove fatal to a human and many other animals over long-term exposure. That such high-level mammals as bats have evolved protection for some of their most sensitive tissues—lungs, eyes, mucous membranes—to such toxins is proof of the ability of living organisms even here on Earth to adapt to "alien" atmospheres. Such creatures provide a potential source of genes or physiological prophylactics to protect or alter other organisms (including man?) to adapt to more inimical environments than currently tolerated on Earth or among the stars.

However far-fetched this may sound, tests are already underway to change human reactions to atmospheric gases by genetically modifying blood. The surprising source of genes for this attempt is that most ancient of reptilian species—the crocodile. When holding one's breath, or in high CO_2 atmospheres, carbon dioxide builds up in the blood as bicarbonate. This can cause humans ultimately to suffocate, but over a much greater range that is of little consequence to the crocodile. Crocodile blood is capable of binding bicarbonate (in a way that human blood cannot) in a manner that permits more efficient release of whatever oxygen is available. Through genetic engineering, scientists have made a human-crocodile hybrid hemoglobin (hemoglobin is the most important functional blood protein) that contains this binding capac-

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ity for bicarbonate without damaging its oxygen transport ability.

Current plans are to attempt to develop the protein as part of a therapeutic blood substitute or as an amendment for certain surgical procedures where it is difficult to oxygenate the patient (Komiyama et al, 1994). It is not technically unfeasible (however morally suspect some may consider it) to envision such techniques (along with many other necessary changes, of course) permanently modifying human beings or other animals for underwater life or for lowered oxygen environments here and in outer space.

Indeed, there are hints that humans have already adapted genetically to long-term low oxygen pressure (Gatenbein, 1993). The Sherpas of Nepal and the Quechua Indians of Peru are mountain-dwelling tribes who show extremely different metabolism from sea-level inhabitants. Their heart and brains have developed altered forms of metabolism that use oxygen far more efficiently. They do not suffer the lethal pulmonary and cerebral (brain) edema that sudden rise in elevation can cause in unadapted humans. Even their mitochondria (the metabolic "power cells" of each individual cell) burn fuel more efficiently, and thereby use less oxygen. These traits, unlike the well-known (and gradual) acclimatization of lowland dwellers to higher altitudes, do not seem to revert upon moving to lower elevations, thereby indicating a possible genetic component. Still, despite these remarkable adaptations to life above 10,000 feet above sea level, stable human colonization on Earth appears to have never established itself above 17,000 feet, perhaps indicating the limits of human adaptability without technological or genetic engineering intervention.

There is evidence that here on Earth dramatic changes over geological time occurred in response to generalized lowered oxygen levels from a high in the Carboniferous period (300 million years ago) of some 35% compared to today's 21%. The extra oxygen may have allowed the more efficient evolution of amphibians with their originally primitive lungs. It might also have accounted for the existence of the gigantic insects found in fossils: mayflies the size of sparrows and dragonflies with the wingspan of crows. The smaller size of today's insects may be a direct response to lowered oxygen. Insects rely on diffusion of their oxygen through their tissues rather than through a blood circulatory system as with higher animals. Less oxygen in the air means a lower diffusion rate, thus the necessity of smaller insects (Monastersky, 1994).

Most currently accepted theories of the origin of life on Earth postulate that there was little or no oxygen in the early atmosphere. The earliest microbial life to arise had to get its energy, grow, and reproduce using a very different biochemistry from most of life in the current day. The planet they inhabited was a vastly different, alien version of our own (Day, 1984). Only when photosynthetic bacteria finally arose which used sunlight as an energy source to split water into its com-

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ponent parts, thereby releasing molecular oxygen, did a large-scale source of free oxygen become available. This oxygen was the first deadly "pollutant" in the life progress of planet Earth. This early life "terraformed" that inhospitable planet to the current image of our own. Countless anaerobic bacteria and related microorganisms, the original ecology of Earth, found themselves poisoned by this new toxic compound in the air. Those which could tolerate or even thrive in the new oxygen atmosphere became the dominant biology. Those which could not perished or retreated to the depths and hollows and the stagnant places of the earth where "fresh" air, loaded with the deadly gas, could not percolate (Osawa and Honjo, 1991). Today the descendants of that great retreat, or those who chose to copy their lifestyle, form the anaerobes—among them some of the strangest of the "extremophiles" on Earth. Anaerobes include a large number of microbial species, bacteria, archaerons, protozoa, and even some fungi, many of profound commercial and ecological utility. Their very lives depend on conditions utterly inimical to our own (Horikoshi and Grant, 1991).

Pressure: Too High

Not only the archaerons, and simple bacteria, but organisms on many branches of the evolutionary tree have developed extreme tolerance to high pressures, as evidenced by their ability to survive in the depths of the sea. Fish and tube worms, mollusks and crustaceans have evolved to live many fathoms below the level where our own fragile bodies would be crushed by the pressure (Lutz and Haymon, 1994). Most are so intimately adapted to these high pressures that their bodies burst or fragment when brought to the surface of the sea, as our own eyes might erupt outward and our blood vessels burst in the vacuum of space.

The mechanisms for such creatures maintaining their equanimity at such high pressures are only recently becoming clear. One of the most critical components is the requisite for maintaining high internal gas pressures of their own. Consider it the equivalent of our lungs being pressurized like the contents of a can of whipped cream. Remove the outside pressure from the can and the contents explode outward. That is the cause of these creatures' instability when raised to sea-level pressures, some 100-200 times lower than that of their normal home. Even slow decompression cannot preserve these creatures from death although major structural damage is averted. Their very biochemistry and genetic systems require high pressure for optimum function (Adams et al, 1995).

Their strange fragility in the conditions we think of as optimal has made study of these organisms tremendously difficult until recently. Now extensive deep-sea probes have enabled us to examine them more consistently in their native habitats. Special pressure traps have enabled scientists to capture these creatures and maintain them alive for much longer periods of time once raised up to the surface and taken to laboratories for study.

Anyone familiar with deep-sea div-

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ing (in film or real life) knows that the human body can be adapted to much higher pressures than we typically face by a slow enough descent and a gradual return to the surface. Special use of oxygenated liquids for breathing can enable even deeper dives (the liquid fills the lungs and prevents the ribcage from being crushed—as it would be if the easily compressible air in the lungs were subjected to such pressures. Consider the case of a beer or soda can. Crushing it by hand is easy when empty, impossible when full).

More intriguing for alien biology and terraforming possibilities, however, is the fact that under such conditions of intense pressure a host of other problems are encountered by biological systems. At these great depths, there is no sunlight. The utter darkness means there can be no photosynthesis—no plant life to produce oxygen or to create the organic matter needed to serve as the foundation of the food chain. Some organic matter filters down from the surface through death and decay of swimming organisms in the higher sea—but in such depths new sources of the energy for life must be utilized. An "alien" biochemistry therefore rules the endless night.

Bacteria at this level use hydrogen sulfide and minerals from volcanic plumes as their source of energy instead of oxygen and sunlight. They act as the "plants" of this high pressure ecosystem—providing a bottom of the food chain for higher organisms that cluster around the deep-sea vents, including crustaceans, tube-worms, fish, and squid (Lutz and Haymon, 1994).

* * *

Rappacinni Worlds

In 1844, Nathaniel Hawthorne wrote a famous short story entitled "Rappacinni's Daughter." It told of a young woman raised by her father on the most deadly natural poisons. Not only did she develop immunity to them, but her very breath and touch were full of death to normal men. This is certainly one answer to the problem of pollution. For, although most efforts at bioremediation are designed to "clean up" the environment, it may, for cost or other reasons, be necessary, as in the case of Rappacinni's daughter, to adapt to it instead.

Genetic engineers have taken a step in this direction by working towards enabling cows to feed off poisonous plants. They have genetically modified the gut bacterium *Butyrivibrio fibrisolvens* that lives in the stomach of cattle so that the microbes can detoxify fluoroacetate (a poisonous compound in trees and shrubs in Australia, Africa, and Central America). When returned to the cow's digestive tracts, the bacteria survive and persist, thereby opening up the possibility of engineering animals to adapt to toxic environments by transformation of their cohabiting microorganisms (Gregg, 1995). On a more positive note, changes in gut bacteria might also lead to enhanced ability to digest hitherto indigestible or non-nutritive feeds—although it is rather unlikely in the near future that using genes from termite gut bacteria would one day enable us to feed cows wood chips! This is in part because most of the microorganisms in the cow's rumen are strictly

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anaerobic (Dougherty, 1965). Oxygen is toxic to their metabolism, whereas the termite gut bacteria are aerobic or oxygen-requiring (Eutick et al, 1973). This difference and the ecological complexity of each gut environment in terms of numbers and distribution of species under varying metabolic conditions preclude the likelihood of an easy transfer of wood-degrading abilities into ruminants.

On Earth we currently have a choice of pasturage and need not rely on grazing cattle on our most polluted lands. But as polluted sites grow along with population, our options may become more limited. And out in space, adapting grazing species (even insects are grazing species, after all) may require adaptation to a toxic alien biology or soil that exists planetwide and not just in small and poisoned pockets here on Earth.

Humans have both beneficial and harmful microflora in the acid soup of their bellies, similar to those in many so-called "lower" animals. These serve as a potential resource to adapt ourselves to alien environments as well—terraforming from the inside out, as it were. And, more importantly perhaps, in a way that obviates the need to tamper with the human genome itself.

Numerous plant species can tolerate by exclusion or accumulation heavy metals that are poisonous to their less hardy relations (Moffat, 1995). Some snails can happily graze on these plants and accumulate high concentrations of heavy metals without being poisoned themselves. Animals like these snails survive by sequestering the metals in special portions of cells, or sloughing off their gut lining when too much of the metal accumulates (Dallinger and Rainbow, 1991). Together, these tolerant species would make ordering salad and escargot in a restaurant on a Rappacinni world a hazardous enterprise, to say the least.

"Improving" on Nature: Bioremediation as Terraforming

There are limits to the adaptability of individual organisms by physiological changes, and to species by evolution. The history of the development of the organism dictates the options available. Genetic engineering attempts to circumvent these limitations by making available the full range of biological adaptation, harvesting genes from viruses to redwood trees, from hummingbirds to humans, as sources of potential survival traits. The attempt to create designer organisms ultimately tailored to these inimical environments is the most cogent first step towards eventual terraforming.

Humanity's own activities have often transformed formerly verdant and pleasant lands and waters on Earth into polluted environments as unlivable for most organisms as any alien world. Oil spills and leakage, industrial pollution, salt poisoning from overfertilization or over-exploitation of groundwater near ocean sites—all can create temporary or permanent "deserts" inimical to life. Strip mining can destroy topsoil and leave permanently inimical heavy metal residues. Acid rains can destroy lakes and forest soils. Atomic testing or nuclear acci-

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dent can irradiate and contaminate land and sea.

In such instances, using creatures from life's extremes may be the only hope of reclaiming the environment to productivity and ecological health. Bioremediation is the process of stimulating natural, or adding additional, microorganisms or plants capable of breaking down or sequestering pollution and reinvigorating damaged soils and water. It is "terraforming" on a small scale—transforming inhospitable "alien" landscapes here on Earth back to a pristine state of health after mankind's interference (or to a state at least approaching economic or cosmetic acceptability, whatever the original cause of the environmental malaise). It is a technology already in use, with its more exotic potentials looming rapidly over the horizon.

The success of bioremediation depends on the genetic makeup of the organisms. Enzymes must be genetically coded that are capable of breaking down or isolating toxic compounds. Genetic engineering can create new combinations of enzymes capable of degrading new types of compounds. In addition, such techniques can transfer the ability to degrade a compound to an organism capable of surviving environments lethal to the original source of the enzyme(s). For example, one could transfer an enzyme from an Antarctic bacterium incapable of growing over 15° to a thermophilic bacterium which prefers temperatures 55° or above. By mixing and matching genetics and environmentally appropriate bacteria, increasingly complex pollution problems might be handled (Davison et al, 1985).

Bacteria have been isolated or created through genetic engineering techniques that are capable of degrading many of the most dangerous industrial pollutants and pesticides currently being produced (Baker and Herson, 1994; Cookson, 1995). Such species are especially important for their potential to break down poisonous residues that are otherwise far too stable in soil or water. Currently most bioremediation efforts are geared towards producing microbes that will break down industrial wastes brought and fed to them under controlled conditions. Far more difficult are the problems of "on-site" treatment.

Already, indications are that complex microbial populations and not just single species (genetically engineered or not) will be required for successful environmental reclamation in many non-laboratory or factory conditions, especially to break down complex industrial pollutants. The need for extensive study of microbial ecology under these conditions makes bioremediation, and hence terraforming, a science in its infancy.

In fact, bioremediation improperly done can make a situation worse (Baker and Herson, 1994). For example, microbial degradation of the pollutant trichloro-ethylene under oxygen-free conditions produces vinyl chloride—a known cancer-causing agent. Similarly, sulfate-reducing bacteria appear involved in transforming inorganic mercury in lake sediments to methyl-mercury, a potent neurotoxin.

More easily controlled than the use of microbes is the use of plant biore-

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mediators, species of which are being tested by USDA for their ability to cleanse the soil of heavy metals such as zinc, cadmium, or lead. Most plant species cannot tolerate these elements at higher than 500 parts per million (ppm) in their tissues. This turns surface lands with high concentrations of metals (usually from mining wastes or natural outcroppings) into toxic wastelands, barren of vegetation. The alpine species known as pennycress, however, is capable of accumulating up to 30,000 ppm of zinc without any yield reduction (Comis, 1995).

Not only can such plants thrive under such poisonous conditions (ideal candidates for Rappacinni worlds), but researchers hope that with select breeding or genetic engineering, these "hyperaccumulators" may be able to concentrate such large concentrations of the metals that they could be harvested and "mined" as a kind of biological ore. This would have as its chief benefit the cleansing of the polluted soil, hopefully after multiple croppings, to levels low enough for less hardy plants to survive, perhaps even for farming to resume. In addition, transfer of multiple heavy metal tolerance and accumulator genes into ever more species would broaden the environmental range of lands that could be treated. This use could make plants some of the most powerful, and least ecologically threatening, bioremediators (Overcash, 1996). Currently there has been some success in genetically engineering Arabidopsis with a bacterial enzyme capable of making the plant tolerant to large concentrations of mercury in the soil (Moffat, 1995). Hyperaccumulator plants have been found that are capable of absorbing radioactive metals such as uranium and cesium from the soil as well. These may provide a valuable tool for post-Cold War clean-up of radioactive weapons' waste and for dealing with fallout from nuclear power plant accidents such as the one at Chernobyl.

Terraforming in Space: Science Fiction?

If we are already developing terraforming techniques for bioremediation here on Earth, what of the long-held dream of science fiction—transforming alien worlds to hospitable colonies? Earth biology already demonstrates the utility of extremophiles to survive and flourish in hostile environments, many of which are similar to those predicted possible, or which have already been shown to be likely upon other worlds or moons in our own Solar System.

Mars may or may not be a current or previous seat of life. But if there are underground hot springs coupled to the water and carbon dioxide already shown to exist there, some of the microbial extremophiles on Earth could be made to thrive there, in pockets at least, if not planetwide. Subsurface lithoautotrophic microbial ecosystems (SLIMES) have been discovered deep in subterranean rocks within the Earth, conditions that could also easily exist on Mars. Some of the microbes in this system live off nothing but dissolved rock and hydrogen gas, providing food for other microbes in their turn (Fredrickson and Onstott, 1996).

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Even more promising hope for a planet to terraform, however, is provided by the latest news from NASA's observations of the Jovian moon Europa. In January 1997, scientists reported that the Galileo spacecraft showed evidence of recent ice flows on the surface, which indicated a hot core of geo-thermal or gravitationally derived thermal activity. This warmth, coupled with the ice and the ubiquity of organic molecules in the Solar System, provides the three things necessary for the evolution of life (Sawyer, 1997). If no Europan life of its own exists, the conditions seem primed for seeding the planet with extremophiles in waters below the ice.

On Mars or Europa, on possible rocky moons around the Jupiter-sized planets already discovered in other solar systems throughout the galaxy, it may be difficult if not impossible to recreate the Earth. But the initial, and perhaps most sensible, goal of terraforming is not to transform the alien landscape but to adapt it to human needs—to create an ecological system capable of feeding and sustaining human life to whatever extent is possible. A microbial soup growing in a self-sustained fashion in the "wild" of alien planets can provide the feedstocks for human colonization.

Extremophiles can make the carbohydrate, proteins, and vitamins necessary to feed more traditional crops and farm animals for human consumption. Plants nurtured on the organic matter and waste products of the extremophiles can make the air that humans will need to survive (even if it must be in domed environments).

Ultimately, with more mechanical (rather than genetic) engineering assistance, using such possible techniques as deliberate global warming, iron seeding of alien oceans, or explosive ignition of volcanic chains—massive changes in the atmosphere might link with large-scale "bioremediation" to truly transform worlds.

But even thinking small seems miraculous enough. Spaceships and artificial ecosystems might be "terraformed" for long-term travel between the stars. Already scientists are working on engineering micro-organisms capable of scrubbing pollution out of the atmosphere of a recirculating spaceship: degrading paint fumes and toxic breakdown compounds of manufactured plastics and alloys, all the things which make for "sick buildings" here on Earth but which would be of far greater consequence out in space where "opening a window" was not a viable option and where charcoal filters might prove limiting in the long haul (Kleiner, 1996).

Promise and Peril

Nature is a lot more complex than it often seems. Individual species do not ecosystems make, and despite the capacity of life to buffer itself, there is obviously a vast capacity for change, both good and bad. Any attempts at bioremediation here on Earth or terraforming out in space have to be examined carefully. We do not know enough yet to set up a completely self-sustaining ecosystem for extended periods of time. Still less do we understand the only working model (the Earth) we have—witness the fact that

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only now are we discovering the full extent of the extremophiles, and in fact, barely scratching the surface of the bacterial population that surrounds us day to day (Gould, 1996).

Biological effects are cumulative, not just short term. Though biology's self-reproducing aspect is a key benefit, it is also the key danger. It's hard to change your mind once the rabbits are loose in Australia, or the fire ants are marching through Georgia. The questions about releasing genetically engineered organisms into our own ecosystems, whether for bioremediation or agriculture, remain controversial. Simple genetic alterations of single species in controlled environments are met with skepticism, in some cases with cause, in others from simple fear of the unknown. How much more problematic would be the release of the complex mixes of genetically engineered microbial species that might be needed to properly do the job of bioremediation on a global scale? How soon would we be willing to seriously address the possibility of extensive terraforming here on Earth? It's hard to practice such techniques in a laboratory.

And what of the larger picture if we hold off and wait until we get to outer space? Some environmental ethicists shudder at the thought of Mars transformed to the Amazon or even to Arizona. Especially if it is not just a barren rock but has indigenous life-forms, however primitive, of its own. Is Terran life to be an infection spread across the Solar System, the Galaxy, the Universe? Even if we can terraform to our hearts' content, someday, the question becomes—how much should we?

It is unlikely that such questions will be solved easily. It is also unlikely that we will be content to abandon our expansion if it requires utilizing organisms adapted from our own Terran biology to help us conquer other planets on an ecological battlefield. The best that can be hoped for, unless we have a massive change of heart, is that the presence of other life-forms will be adapted to and accepted. We once adapted to and were forced to accept many of the animals and fruits of the New World—no matter how much we attempted to transform the American landscape into a distorted mirror of the Old World.

In theory, genetic engineering, using some of our developing knowledge of life here on Earth, might one day be able to help adapt humans to alien biologies should they exist in other solar systems. By changing our gut microflora, altering our lungs and blood, hardening our skin, changing the thermotolerance levels of our cells and our sensitivities to poisons or radiation using biochemical lessons learned from the extremophiles, we could, perhaps, change ourselves enough to live on such planets without extensively terraforming their alien ecosystems. But how less ready are we for those ethical dilemmas? Will we, who can't quite manage racial or national harmony, be ready to risk creating a foreign species from our own? ■

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BREAKING THE STANDARD MODEL

These days, experimental particle physicists spend much of their time banging their heads against a brick wall called "The Standard Model of Quantum Chromo-Dynamics." It's all very frustrating. The Standard Model is in good agreement with essentially all of the data collected by particle physics experiments during the past decades, yet it is not a theory that provides any deep understanding of the inner workings of the Universe. It depends on about two dozen arbitrary "constants": particle masses, force strengths, and interconnection strengths. We have no idea where these constants come from or how they are related to each other. We know there must be a better, more fundamental theory behind this knock-up facade. Therefore, particle physicists, along with their other activities, have been trying to make the Standard Model "break," to find places where its predictions fail, to find a crack in the brick wall which might provide some inkling of what lies behind it.

So far this has been a lonely and unrewarding quest. New experiments occasionally come along which point to a breakdown of the Standard Model, but up to now they have invariably been proved wrong by more careful analysis or subsequent experiments with better data. A case in point is the energetic jet data from the CDF experiment at FermiLab that suggested possible substructure of the quark. (See my AV column "Inside the Quark" in the September 1996 issue of *Analog*.) The CDF group found an unexpected excess of "jets" (clumps of energetic particles moving in the same direction) with energies above 200 GeV in their data. They found that they could not explain this excess of high energy jets using the Standard Model, as interpreted by standard theoretical procedures, and they pointed out that the data might represent new physics, possibly an indication that the quark is a composite object made of even more fundamental particles.

This quark substructure "discovery" lasted about half a year. In that time, particle theorists found that minor changes in their assumptions about the velocity profiles of quarks and gluons within the proton could explain the data without significant changes to the Standard Model itself. My column discussing the CDF data (because the *Analog* publication

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pipeline takes about five months) appeared in print at just about the time when the quark substructure effect was being explained away.

Does this mean that the quark has no substructure? No. It only means that even if a substructure is there, finding it is probably beyond the capabilities of presently available particle accelerators. To observe such effects directly, the collisions would have to be much more violent than those we can presently produce.

However, new data from two groups at the DESY (pronounced "daisy") accelerator laboratory in Hamburg may suggest indirect evidence for quark substructure. Let me begin by describing the DESY collider, which is called HERA (Hadron-Electron Ring Accelerator). It is remarkable that the entire HERA synchronotron ring accelerator has been constructed in a tunnel bored through the rock and subsoil directly beneath the city of Hamburg. This placement of a major particle accelerator in a tunnel under a major metropolitan area points to an essential difference in attitudes toward scientific research in Germany and the USA. Imagine the public outcry if, in 1987, the US Department of Energy had announced that it intended to construct the Superconducting Super Collider in a tunnel beneath New York City, Chicago, or San Francisco! Imagine the hearings, the environmental impact statements, the protests of outraged citizens, the feeding frenzies of the lawyers . . . But somehow, the Germans have done the equivalent of this with essentially no public opposition. With careful planning, the support of state and local governments, and deeply ingrained public respect for science, the HERA collider was constructed deep beneath Hamburg.

HERA is also unique in colliding dissimilar particles: 27.5 GeV electrons with 820 GeV protons. The SPS collider at CERN and the Tevatron collider at FermiLab produce head-on collisions of protons with antiprotons. The LEP collider at CERN and the Tristan collider in Japan collide electrons and positrons. The new LHC collider now being constructed at CERN will collide protons with protons. Only in HERA collisions does a lepton (an electron) collide with a quark (one of the three inside a proton).

The HERA experiments H3 and ZEUS, after searching their three-year inventory of data, are now reporting observation of events that seem to be incompatible with the Standard Model. Both experiments observe rare events in which the incoming electron strikes some "object" deep within the proton that bounces it back in the reverse direction with almost its initial energy and momentum, producing a jet in the opposite direction. The probability that random fluctuations in the "standard" behavior of the quarks and gluons in the proton could produce the observed effects is only a few parts per thousand. Thus, unless new calculations alter the odds, there seems to be a very good chance that the Standard Model has been broken by the HERA data.

In order to produce the effect observed in the HERA data, the object

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The red light on my portaphone blinked not quite in time with the few Christmas lights I'd strung to decorate my spare apartment. I answered, "Yeah?"

"Morgan. This is Capt. Phillips. We have an assignment. A big one. Code one. We need you to report to Command."

"Oh, c'mon, Mark," I said. "Cut the official bullshit. I'm a civilian agent now, remember? And it's Christmas time, for crying out loud. What kind of mission do you need me for?"

"All right, Jake," he said. "How would you like to spend Christmas in a Christmas card?"

"What the hell does that mean?"

"You'll find out when you get here."

"And about that—why me? I'm not on holiday duty. I'm supposed to have this week off," I protested.

"You're the best."

"Horseshit."

"OK. The best that's also single. Did you actually have plans this year, Jake?" He knew I didn't. I never did. He continued. "What do you want me to do—send an agent with a family he could otherwise be with? All you're going to do is sit on your butt in your apartment and you know it. This will do you good."

Mark is a great boss and a good man, but he knows me altogether too well. I sighed. "OK. What is it I have to do?"

"You're going on an Easter egg hunt, and that's all I'm telling you until you get here," he said, and he signed off.

I took a hopper over Mare Crisium from Luna City to the High Command complex buried under the mountains on the north end of the mare. The System Patrol had originally had just a landing field out there, but had built on to it and hollowed out tunnels in the hills, and what with the war with the Belt a few years ago, the place had ballooned into a huge underground complex. I'd never followed all of the hallways and corridors, mainly because Mark had his office in the first tunnel in from the landing bays.

I berthed the hopper, went through the usual checks, and was with Mark only one hour after he'd called. He was already at his desk when I arrived and he got right to it.

"Know what this is, Jake?" he said, holding up a chrome shiny egg-shaped and -sized object, swinging gently from a lanyard strung through a small loop on the end.

"An Easter egg?" I ventured.

"That's right. Or rather, this is a mock-up. The real ones are too dangerous to keep around."

He handed it to me. I was surprised by its mass—easily four kilos. That wasn't anything here in Mark's office—the High Command still keeps the base at normal Moon gravity. But you wouldn't want to lug the thing around for long if you were in the one *g* pseudograv field of Luna City.

The device only had two buttons on it and a small indicator display. I played with the buttons. One was for setting times. The other was a scale that went from .5 KT to 12 KT, whatever that meant. I gave Mark a quizzical look.

"It's a dial-a-yield nuke. Good for half a kiloton to twelve. This is a top-

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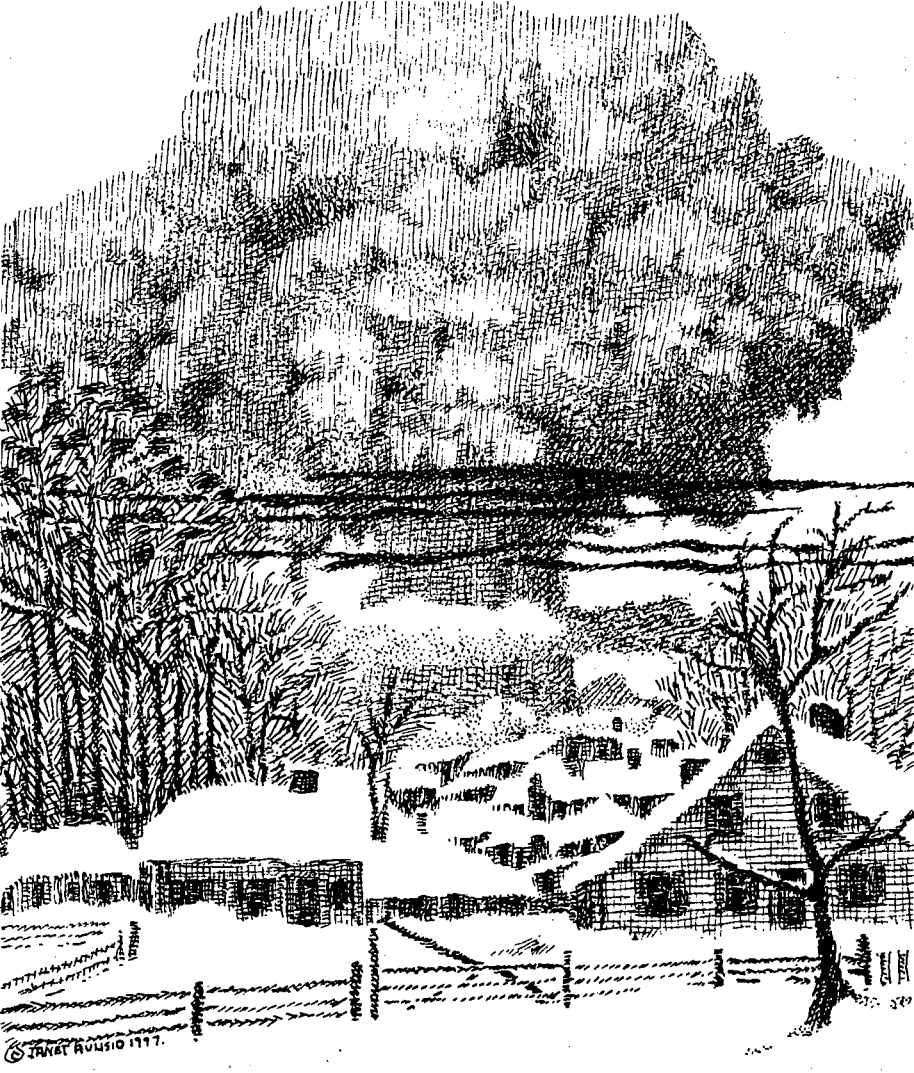

People "know" many things. But there's knowledge, and then there's knowledge. . . .

Illustration by Janet Aulisio

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Jeffery D. Kooistra

EASTER EGG HUNT: A CHRISTMAS STORY

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virtual reality and political posturings and video games, and allow the inevitable plagues and asteroids and tidal waves of evolution and change to wash us away, to be replaced on the planet by a more promising species.

AV Columns On-line: Electronic versions of 85 or so past "The Alternate View" columns by John G. Cramer are available on WorldWideWeb at the URL: http://www.npl.washington.edu/av. ■

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See also the DESY/HERA web site at:http://www.desy.de/pr-info/desy-recent-hera-results-feb97_e.html and the ZEUS high Q^2 web site at:http://www-zeus.desy.de/~ukatz/ ZEUS*PUBLIC/hqex/hqex*highx.html

IN TIMES TO COME

Our lead story for the first issue of 1998 is Rick Shelley's novella "Beacon." When space travel is commonplace and farflung, what's a pilot to do when trouble strikes far from any center of civilization? The civilization in Shelley's universe has constructed a partial solution in the form of scattered stations for the express purpose of providing places and equipment for pilots in distress to make emergency repairs. But what do you do when a big incident brings more than one pilot to the same shipwreck station—and one of them is *very* alien? Particularly when, after the initial shock wears off, you realize you're dealing with a completely different *kind* of distress . . .

Our fact article is a bit different: professional diplomat Michael A.G. Michaud's view, not of *how* we might make contact with extraterrestrial intelligence, but of what we might say and do after that happens. It seems the matter has received more official attention than you might realize. . . . And, of course, we'll also have a varied assortment of shorter fiction by such folk as Ben Bova, H.G. Stratmann, and Joseph H. Delaney.

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or a better and more deeply penetrating successor to the Standard Model emerges from current research in particle physics. What difference does that make to our everyday lives? What new commercial products will be built using these discoveries? How will it ease the burden on the taxpayers who ultimately pay for the research? Or even, how much will the populace be entertained, as they are to some extent by NASA's space shots and planet close-ups?

As a physicist I have found three ways of answering questions like these. First, if we look back at the scientific discoveries and related technical applications of the previous century, it is clear that key concepts and discoveries cannot be anticipated. We must first allow science to progress and then use the ideas, concepts, and insights which emerge. We can track, for example, the personal computer, the smoke detector, the television, and the MRI imaging technique back to their origins in the discoveries of current control using solid-state physics, of transuranic elements produced using nuclear reactions, of electron beams manipulated and focused using electromagnetic fields, and of nuclear magnetic resonances in atoms. But it would have been impossible for the early-20th-century scientists working in these fields to anticipate the impacts of their discoveries. We know from experience that, overall, basic scientific research always pays off, but we cannot predict where or when the payoffs will come.

Second, gaining deeper understanding of the way the universe works alters our view of our society, our planet, our Universe, and our place in it. We come to realize how delicately tuned are the physical constants of the Universe which make life and civilization possible, how rare and unlikely intelligent life and civilization must be. I refer interested readers to my column "The 'Real World' and the Standard Model," which is about this aspect of particle physics. It was published in the May 1996 issue of *Analog*.

The third kind of answer, the one I like best for its honest and straightforward arrogance, was given by Robert R. Wilson, then director of FermiLab, when he was testifying before a congressional committee in the 1970s. A rather hawkish US senator asked him whether current research particle physics would contribute to the defense of our nation. Wilson, resisting the trap of spinning some extrapolative fairy tale about ultimate impact or resorting to NASA-style "spin-off" hyperbole, answered, "Senator, particle physics research is not likely to aid in the defense of our nation, but it *will* make our nation worth defending."

He meant that when our civilization loses its compulsion to push back the frontiers of knowledge, to want to find out what is behind the next intellectual barrier, to discover the answer to the next question, to peer ever more deeply into the heart of the Universe and learn the secrets of its innermost mechanisms, then perhaps we are done as a civilization. We should, when we reach that point, retire to a vegetable existence of man-made diversions, to MTV and soap operas and

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struck within the proton would have to have two characteristics: (1) it would have to be very massive, and (2) there would have to be a very large force between the electron and the struck object, a force on the scale of the strong interaction. The problem with this combination of characteristics is that while massive components can be found within a proton, the Standard Model requires that leptons do not have strong interactions either with other leptons or with quarks and gluons. As far as we know leptons only participate in the weak interaction, which has only about one one-millionth the strength of the strong interaction. This suggests that the object struck by the electron (or created in an electron-quark collision) is an entirely new particle, christened the "lepto-quark," which is very massive and which has strong interactions with leptons. If such a particle existed, it would "break" the standard model, requiring extensive revision of the basic theory and perhaps bringing onto the fundamental particle scene a whole new generation of particles.

This possibility has already been anticipated by some particle theorists. Even before the new HERA data was reported, many theoretical papers were published that speculated on the properties of lepto-quarks and described ways in which experimental data might be analyzed to find them. More than 14 sub-species of lepto-quarks with differing properties have been proposed in various theoretical papers that use an array of theoretical models with names like grand unification, supersymmetry, technicolor, and preon substructure.

In a previous column ("Inside the Quark," *Analog*, September 1996) I discussed preon models that describe quarks and leptons as constructed of even more fundamental particles called "preons." Such models can include lepto-quarks by combining preons in alternate ways. In most of these variants of the Standard Model the lepto-quark is a massive boson (integer spin), which has non-zero quantum numbers for being both a lepton and a baryon (i.e., it has the quantum characteristics of both an electron and a proton). Like a quark, the lepto-quark should have a net color charge and a fractional electric charge.

The particle physics community is now awaiting more data from HERA and more careful analysis of the available data. The burning question is, has the Standard Model been broken, or will the HERA data be explained away like the "quark substructure" data from FermiLab? Are we on the threshold of a new breakthrough discovery about the fundamental substructure of the universe, or must we continue to grind out more confirmations of the Standard Model, punctuated by "discoveries" that are ultimately explained away? I'll try to keep you up to date on these questions in future columns.

There are other questions raised by discoveries like this one that are often directed at particle physicists: "So what?" Suppose the Higgs boson is found, or a lepto-quark is discovered, or some new and previously unanticipated force of nature is found to exist,

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secret commando device. Tell anyone about it and I'll have to kill you." He smiled when he said that but he still might have meant it.

I'd never heard of a variable nuke being this small, but I took what he said in stride. "How does it work?"

"Kind of simple, actually. A slurry of fusion fuel, a hypercapacitor, and some nifty work with Dykstra shield technology. A minute fraction of the slurry is flash compressed to fusion and that sets off whatever fraction of the rest you set to have detonated. This ain't the kind off thing you'd like to lose in your apartment, is it?"

"No," I said. "So where did we lose one?"

"It was stolen," Mark said. "One malcontent commando went around the bend and left one on Earth with some folks he just didn't like. We know who those folks are. We know it's set to go off some time Christmas morning. That just leaves thousands of square kilometers to search."

"No problem," I deadpanned. "What will I do to fill up the rest of the afternoon?"

We got down to details. Mark turned on his wall display and showed me a map of the northeast coast of what used to be the USA. "Right there, Jake. The Republic of Currier and Ives. He left it somewhere down there."

"Those nuts?" I said. The inhabitants of Currier and Ives were a throwback group, with the most restrictive laws on Earth, enacted in a vain attempt to roll back the clock.

" 'Citizens,' Jake."

The commando's name was Manfred Rolff. He'd actually grown up in Currier and Ives, but Mark didn't know what had made the guy mad enough to leave a nuke hidden down there. We'd never find out, either—Rolff had been psychotic, and the other commandoes had been forced to kill him when they tried to bring him in.

I spent the four-hour shuttle trip down to Earth reading up on Currier and Ives. The nation was formed shortly after the Collapse out of the former states of Maine, Vermont, New Hampshire, and parts of Massachusetts. Their philosophy, I discovered in my reading, involved trying to create a society that adhered to the "old US as described by Tocqueville in *Democracy in America*," whatever that was. Also, they'd wanted to make a country that actually looked like prints from old Currier and Ives Christmas cards, plates, tins, and whatnot. The theory was that the Currier and Ives prints captured a "spirit of America," an America that was good and wholesome and worth living in.

To each his own, but I sure as hell wouldn't have wanted to live under their load of laws and regulations. Visions of a list of "thou shalt nots" a kilometer long rolled through my mind.

Mark had told me that the governor of Currier and Ives would meet me at the spaceport, someone named Joe Wood, and he was the only one who knew why I was coming. He'd insisted on dealing with me himself, and not through some underling.

It didn't matter much, not as far as I could see. No matter who met me, af-

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ter landing I'd only have thirty-six hours to find and deactivate the Easter egg before it went off and made the Christmas card look like season's greetings from Hiroshima.

The shuttle fell slowly out of the sky over the frosty Atlantic Ocean. I'd been born in the desert southwest, so oceans weren't something I was used to. Besides, that was forty years ago, and I hadn't been down to Earth in a decade.

Approaching the coast, I could see that Currier and Ives was certainly going to have a white Christmas this year. The land was white from horizon to horizon, though at the moment the sky was crystal blue.

The Patrol shuttle grounded on the large but vacant local pad, and took off again even before I finished walking through the short tunnel and into the reception area. This being the holidays, ordinarily the place should have been packed with tourists—families of sentimentalists showing up and hoping to find the true meaning of Christmas in the manufactured landscape of Currier and Ives. But the place was empty. I assumed that the powers that be had concocted some kind of cover story to explain why the number one Christmas vacation spot in the Solar System was shut down until after the holidays, but I didn't know what it was.

The reception area was a large, L-shaped room. I looked out a window and saw rows of empty stables, and outside of each, a sleigh standing ready. There wouldn't be any sleigh rides this Christmas.

When I said the place was empty, I meant the governor wasn't there either. That ticked me off. I hoped he'd show up soon since I didn't have much time. I didn't know what kind of a nut he was going to be.

I walked toward the back of the room and turned the corner. I found the true meaning of Christmas.

I looked over the elaborate Christmas display erected back there. I had to admit, the place looked like it was supposed to—I'd never seen a more perfectly traditional display in my life. The crèche was amply supplied with fake animals—cows, horses, a donkey, pigs, sheep, goats, a few chickens, and the stereotypical Joseph and Mary and manger Jesus, the last complete with a cheery angelic glow. Shepherds and wisemen rounded things out. Also on display was a classic Santa Claus, with a bag full of toys and two elves joining him on the sleigh with the customary eight reindeer poised to leap into the sky. Between the two was a splendidly trimmed Christmas tree, done with remarkable taste—all bright shiny ornaments and tinsel, and just enough strings of solid white lights to fill completely without looking crowded. Holly and ivy and white candles filled out the room, and there was a roaring fire in the fireplace, and a tray of chestnuts at the ready.

I tried to ignore the sentimental feelings welling up inside of me, but it wasn't easy. These folks knew how to decorate. I kept my mind focused by trying to find flaws in the display. After some minutes, I decided the Christmas tree was leaning just a little bit to the left, but that was the only

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fault I could find.

I was trying so hard not to get sentimental because it would lead me down a bitter string of memories—of parents divorced when I was young, of a cocaine-addicted mother and an abusive father, and me ultimately sent to a boys' home at the age of six. Christmas had always been the worst for me. Though the men and women at the—hell, let's just call it the orphanage—did what they could, presents donated by the local churches just couldn't match up with the cool stuff the other guys brought to school with them after the holidays.

Silly? Yes. Petty? Yes. But I'd been well into my twenties before I was able to shake off the bitterness of my youth, and every lonely Christmas still found me particularly vulnerable.

"Hey! Morgan? Are you here?" The call came from around the corner back by the entrance. I went back that way and saw a stocky woman who would have looked like the Santa on the sleigh if she'd had a beard.

"Right here. And you are. . . ?"

"Governor Wood." Oops. "Joe" was actually "Jo." "Sorry I'm late," she said, "but one of my horses threw a shoe on the way over, so I had to cut her loose and let her limp home. And a one-horsepower sleigh doesn't go so fast through unplowed snow."

"You came in a sleigh?"

"This is Currier and Ives, remember?"

"But time is critical—" I began.

"Sonny, I would have been here to greet you upon your arrival if things had gone right. Anything with a motor can break down, too."

I had to admit she was right about that, but how the hell did she expect us to search much of the area in a damn sleigh? "OK, fine. You know what we're up against?"

"Sure. A mini-nuke with variable range yield, and we'll have to assume it's set to go off at the high end. At twelve KT that means everyone within a mile radius of where the bomb is will be in for a hell of a bang. Since it's a pure fusion device, we don't have to worry about radiation, and the snow will probably help put out whatever fires are lit outside of the range of blast damage. Still, all the way around we're better off if we find the thing. Where could it be?"

She reeled off that statement almost too fast for me to follow. I guess I'd been expecting the Governor of Currier and Ives to be some backward, ignorant redneck or something, and certainly a man, but Jo Wood was far from fitting my stereotype.

"Now, I don't want to tell you your job, you being from the System Patrol and all, but as I see it, assuming old Manny actually came to this spot and not another, he couldn't have gotten more than a few miles from here before someone would have seen him, so that limits the area we have to search. As far as that goes, he used to live two miles down the road, so that might be the best place for us to check first."

"Old 'Manny'?" I asked.

"Sure. The son-of-a-bitch, pardon my French, used to live in Currier and Ives. We threw him out four years ago. I personally saw him off right from this terminal."

"Why was he sent away?"

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" 'Banished' is what we call it. He was caught screwing a fifteen-year-old girl."

"Rape?"

"Technically yes. We could have hung him at the time. No, she gave her consent, but the age for that is sixteen, and then only legal if you get married first."

"But the age of consent everywhere else in the whole Solar Union is fourteen," I pointed out.

"But not here. That's why we sent him out to you folks. Under the circumstances I think we were lenient."

"But she gave her consent—"

"Yeah, and she looked older than her age, too. So what? Even if she didn't know better, he was supposed to. He knew what the penalty was if he got caught, and he chose to ignore it. Anyone that reckless and stupid isn't someone we wanted to have around."

"But—" I started again, then realized I was on my third "but" and shut up. I wasn't here to argue with these people about how they lived their lives. "So you think maybe he would have left the bomb at his old house?"

"No. I think he would have just heaved it from the platform out somewhere into the deep snow, if he could do it when no one was looking. But if he did that, we're never going to find it anyway. Those suckers are stealthed, so a radar scan couldn't distinguish it from all the rocks out there under the snow."

That was enough for me. I had to know: "How do you know so much about these little nukes?"

By this time we were on the way to the sleigh. I'd brought a coat from the High Command stores, so I was warm enough, but on the walk through the snow I realized I'd need some other footwear. "I wasn't always a governor, you know," Jo said. "I used to design weapons for the Patrol, as a matter of fact." Then she fixed me with a stare. "You were expecting a backwoods, know-nothing hick, weren't you? That's all right. I forgive you. And just to show there's no hard feelings, I'm even going to give a greenhorn like you my husband's best pair of boots to wear."

The sleigh ride was incredibly smooth, or at least it struck me that way. I'm used to flying everywhere, so I guess I'd expected the ride to be bumpy, but we glided along with our one-horsepower (her name was Nellie Sue) motor with barely a jostle.

But it was damn cold.

"Starting to shiver, Jake?" Jo asked after we'd been on our way only a couple of minutes.

"It's the wet feet," I said. That, and being used to a controlled environment.

She smiled and then surprised me thoroughly by reaching under the front board, pulling out a small control box, and suddenly the seat was enveloped by a Dykstra shield windscreen bubble and warm air was pouring out from beneath my feet. "I don't get it," I said. "This sleigh has a heater? That isn't authentic."

"So what? Currier and Ives is supposed to look authentic, but we're not a bunch of ascetics. We like the pace of sleigh travel in the winter, but who wants to sit in the cold? We like the look and the feel and the heart of the old ways, but it has to be within *reason*."

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I was beginning to understand how badly I'd misjudged this place. Jo certainly wasn't a nut. Maybe they had some odd laws, and archaic ways of looking at things, but it was beginning to look like they really could turn the clock back. At least in some ways. At least for a little while.

Until someone decided to blow the place up.

Jo was pointing. "See that homestead over there—that yellow house? It's copied from a classic old Currier and Ives print. But all of the wood in that house is thoroughly treated. It's not going to suffer from termites or dry rot."

I did recognize the house, from a print called "A cold winter morning." The recognition of the scene did something warm inside me. Before the string of associations could start again, I shut it off with another question.

"Are all the homes in Currier and Ives taken from old prints?"

"No, but they're all built in the old style. This is the course where we take the tourists around, and the town is made to look authentic, too. But we have a very limited number of people we let in. The waiting list for reservations is years long."

"What kind of excuse did you use to explain to the business community why you shut down the Christmas tourism business at the hottest time of the year? The businessmen must have gone ballistic."

"No, I wouldn't say that. You're not going to understand this, but what I told them was the truth."

"You what? But those Easter eggs are classified! And what about the panic—"

"Do you see any panic?"

"Uh. No."

"That's right. And as far as classified goes, not in the Republic of Currier and Ives. I told them the exact circumstances of what was up, and they all understood why we had to close down. We don't have anyone here who has a panic attack every time he hears the word 'nuke.' "

We passed a spot on the side of the road where a sleigh trail came out of the woods. "I live down that way," Jo said. "The team hasn't been through yet to plow off the snow. That wouldn't have mattered if Mary Lou hadn't thrown that shoe. I could have gone through it easily. I hope she makes it back to the house all right."

There was another thing I wondered about. "Why you, Jo? Since everybody knows the truth about why I'm here, you didn't have to be my guide to keep it a secret. Why didn't you just have one of your aides take me around since it's the holidays?"

" 'Aide', " Jo said. "I only have one assistant. And Andy has a family, that's why. A wife and two little ones. He should be home with them. My kids are long gone—one's in orbit around Venus, and my girl is about seven thousand klicks to the west and three klicks down at Pacifica. And my husband passed on years ago.

"How about you? How'd you get stuck with this chore?"

I just chuckled. "Same reason. Everyone else has family to spend Christmas with."

"Well, then, I guess you'll just have to spend it with me," Jo said. "That is, if we're still here."

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Ten minutes later we came in view of another farm house. Typically New England in design, but I didn't recognize it as coming from any Currier and Ives print I'd ever seen.

"This is Buck Black's place," Jo said. "This is where Manny was a boarder for awhile. Buck's daughter is the girl that Manny was caught with, so if Buck had seen him, his body would have been leaning frozen stiff against the barn and waiting for us. I don't see it, do you?"

I wasn't sure if Jo was being serious or not, and I didn't pursue it.

We pulled up to the front porch, but then Buck came out of the barn from behind us. "Hey there, Governor. Merry Christmas. You too, stranger."

Another stereotype shot to hell. Buck Black was a black man, probably in his fifties, and I could tell he was put together like a tree even through the bulky coat he was wearing. It had just never occurred to me that Currier and Ives would have anyone other than white people living in it, but I couldn't honestly say what had made me think so.

"This is Jake Morgan, Buck. The man from the Patrol."

"No, I didn't see Manfred around here," Buck said without being asked. "If I did, you would have found his dead, frozen ass leaning against the barn." Jo gave me a glance at that and a wink. He went on. "Livvy's a changed girl now, since she's married and had the baby. No more wild oats to sow in that girl. But I'd never let that bastard come around again."

"You did tell her that we think he may have planted the bomb around here, didn't you?" Jo asked. "I know she doesn't have a TV or even a radio out at her place."

"'Course, Governor. I asked her if he'd been around, and she shuddered, said no, and ran for her Bible. Didn't actually get to mention the bomb. But I told you, she's a changed girl. She's a good girl, now.

"Now, you two want to come in for a cup of coffee?" I could tell by the way he asked that he didn't want us to accept.

"No. Thanks anyway, Buck. It will be dark by the time we get back to my place as it is, so I guess we'll just head out." Black looked relieved and we turned around and headed back the way we came.

Here this was my mission, and I hadn't even asked the guy a single question myself.

"Buck comes from a very strict Baptist background. He died inside when he caught his little girl with Manny. It was his wife who'd wanted to take in a boarder. I don't know if he ever forgave her, but once she died the light went out in his soul. At least, until Livvy got married and gave him the granddaughter. Now he's overprotective, but he's a good man."

"Are there a lot of people like him here in the Republic? He seems hostile to the world."

"I wouldn't say a lot. Buck just wants to be left alone. The world can go its way, and he'll go his. Nothing wrong with that."

The governor's home was another place out of a print. The inside looked like it came from a print, too; it was

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all comfortable and warm. The house had a big fireplace and I helped the governor carry in wood from the woodpile, but only after we'd gone inside and she got me that pair of boots she'd promised me.

Supper was ham and corn and beans and sweet potatoes and baked potatoes, finished off with apple pie *à la mode*. The governor fixed it all herself, too. Granted, her kitchen did have most of the modern stuff so it took her only fifteen minutes to prepare from a standing start, but the food was Earth-fresh and -grown (it does make a difference!), and by the time we were sitting in front of the fire at seven o'clock (1900 hours, though it was actually 0400 Luna time) sipping hot cider and brandies, I was feeling pretty good about the Republic of Currier and Ives.

It'd be a pity if this particular part of it was blown to hell.

"Tomorrow we'll go into town and you can talk to some folks who knew him a lot better than me," Jo said. "Besides, the town is another place he might have wanted to hide the bomb, though no one says they saw him there, either."

"This is a hopeless pursuit, isn't it?" I said. "You knew that before I came, too."

"It's the nature of the problem," Jo admitted.

Manfred Rolff had left us with an impossible task. A mini-nuke—leave it anywhere within a kilometer or two of what you want to destroy, and that's all you need to do. All the commandoes had been able to get out of him was the approximate time it was supposed to go off, and that it was in Currier and Ives (they'd actually caught up with him in Peru). It wasn't at all certain that Manfred would have even come to this part of the Republic, despite the local connection. If he had wanted to wreak maximum financial havoc, he could better have left the bomb up in the New Hampshire region where the posh ski resorts are, or further up the coast where the bulk of Currier and Ives brand seafood gets processed.

Mark had been honest with me before I left that this mission was likely to be a failure. But as he'd put it, for political reasons, the Patrol had to at least send someone to try.

I wondered about that, though. Had Mark suspected that Jo would have told the entire population what was up? He said he'd have to kill me if I let out the secret of the Easter egg. Mark is a decent man. My guess was that his superiors just wanted him to send someone down to look around. Then they'd wait for the bomb to go off, decry the disaster to the press, deny the real cause, and wait for the furor to go away since, after all, those folks in Currier and Ives were just a bunch of nuts anyway.

Jo and I talked, just talked, about things, her kids, her husband. I even opened up a bit about my past, and I couldn't even remember how long it had been since I'd done that with anyone. But something about the place made it feel all right to talk about anything, I guess.

Jo turned in by nine o'clock. I told her I had to call Mark to tell him how things had gone today and she showed

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me to her phone. Despite this being Currier and Ives, it was as modern as any phone in the outside world.

I wanted to wait until 11 o'clock before calling Mark since he'd be at the office by then. I got myself another cider and brandy and tried to think like Manfred Rolff.

I couldn't. The man had been a commando—one of a select few of a select few to begin with. And then he went renegade. He would have been smarter than me, more highly trained than me, crazier than me. I didn't have a clue.

I turned out all the lights except those on the Christmas tree and turned my chair around so I could look out the window. A light snow was falling. I had forgotten how bright it is outside even in the night time on a world wrapped in winter. The branches on the trees had become fluffy white wands working magic on the sky. . . .

I sat bolt upright. Had that image come from me?

I glanced at the clock. It was after eleven. I put thoughts about my possible poetic soul on hold and called Mark. It didn't take long to fill him in on what little I'd discovered so far.

"Well, it's an impossible mission, anyway," Mark said. "Just do your best tomorrow. Who knows? Maybe something will turn up. But you're allowed to interpret 'Christmas morning' as rigidly as you want. If you're on a shuttle out at exactly midnight tomorrow that's working up to the last minute as far as I'm concerned. Then you'll still be able to spend Christmas at home."

"Yeah. Thanks, Mark," I said and signed off. Christmas at home? I looked out the window again. The clouds had parted and I could see Sirius chasing Orion. I heard a sharp POP from the fireplace and saw a brief blaze flare up, reflected in the window pane. The aroma of supper was still in the air. Earth fresh *did* make a difference.

I knew I'd be here to watch the sunrise on Christmas morning.

Sans mushroom cloud, I hoped.

The next morning we set off again in the sleigh, this time with both horses pulling (Mary Lou had made it back just fine).

"It's Christmas Eve morning in Currier and Ives and we're on an Easter egg hunt," Jo said. "Do we know how to have fun or what?"

"I'm glad you can keep up your spirits," I said. "I don't even live here and I'll feel terrible if we don't find that bomb."

"I won't be happy if it goes off, either," Jo said. "But I'm not going to look any harder with low spirits than with high ones. That's an attitude that comes with living here, Jake. Why do you think I gave up my commission and left the Patrol?"

"I didn't know you had a commission."

"Full colonel, sonny. Could have been a general. Could have been getting pimples on my butt from sitting in on too many strategy meetings. That wasn't for me—not when I could come here." She swept her hand in an arc for emphasis.

I followed the curve of her swing and noticed the frozen river with a

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few dozen people in warm-looking, earth-toned, ancient winter gear, happily skating from bank to bank—over here, a father giving his little girl her first skating lesson—over there, teenagers playing crack the whip.

"I've seen this print, too," I muttered.

Jo heard me. "Yeah, but that was Central Park, I think. Hardly matters, does it? Did you ever learn to ice skate, Jake?"

"No," I said. "No, there was a shortage of natural ice in Phoenix, and the orphanage couldn't afford to take us down to the arena to learn there. Actually, I doubt if anyone ever even thought of it, that young boys might want to learn to ice skate."

"When our mission is done I'll teach you," Jo said.

"What?" Just then I realized that I'd uttered that last sentence out loud. I'd thought I'd said it to myself.

"How to skate, of course. How else will you ever learn to get around on Mars?" she asked whimsically.

"Heinlein. *Red Planet*, right? The frozen canals."

"You're a good boy, Jake."

Someone had come off the ice and was waving to us. We pulled up and waited. It was a girl. Very pretty one, too. Long brown hair, brown eyes—she looked about twenty. "Hi, Governor. Mom wanted me to be sure to tell you that the man from the Patrol is welcome for Christmas dinner tomorrow, too."

She looked at me. "Is that you?"

"Sure is," Jo said. "Sarah, this is Jake Morgan. Jake, Sarah Proctor."

"Pleased to meet you," I said.

"Likewise, Mr. Morgan. I hope you'll have some time to tell me about life on the Moon tomorrow." She went back to skating.

"Nice girl, Sarah. Unattached," Jo said slyly.

"I'm way too old for her," I said.

"Now, Jake. You can decide if she's too young for you, but only she can decide if you're too old for her."

We continued on and the path soon curved away from the river. I could see the steeple of a church rising above the low hills maybe a kilometer ahead of us. Off to my right was another small house set back from the road.

"What about that place," I asked, pointing. "Anything special there?"

"I doubt it. Manny was gone before Zach and Zane moved in there."

" 'Zach and Zane'? Twins?" I asked.

"Nope. Just buddies as far as I know. *Very* good friends."

"They're homosexuals. Is that what you're saying?"

"Some suspect. They don't say and we don't ask, and they don't act like it in public."

I suddenly remembered those restrictive laws. I'd forgotten all about what an intolerant place this was. I ventured a hypothetical question. "What would happen if someone came to you and said he'd looked through their window and seen them making love?"

Jo seemed to think about it for a moment. "Banishment, I'd think," she finally said.

"You'd actually banish them for something they did in the privacy of their own home, not hurting anybody?"

"Not *them*," Jo said. "The jerk that

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was window peeping. Nothing would happen to Zach and Zane. Who'd take the word of a peeping tom on anything?"

"Oh," I said. I didn't know if I was satisfied or disappointed with her answer.

"You took the bait, Jake. That's why I dropped that hint. I used to think the folks here were a bunch of intolerant, backwards jerks myself. Then I came here on a visit once when I was in the Patrol. We needed the services of a real blacksmith. And don't ask me why—it's still classified. Currier and Ives was just starting to roll, then.

"Anyway, what I learned then was to question what it is I think I know about people, or anything, for that matter. You know the old saying, about the problem being 'what we know that ain't so'?" She was looking at me like she expected an answer.

"I've heard of it," I said.

"Well, after that visit, I realized that what I thought I knew about Currier and Ives was all based on what other people said. Now that's fine, but I was assuming that all of them had at least been here or had some reason for knowing what they were talking about. And that's lots of times just not true. Turned out I loved the place, and my husband and I used to come here on vacation every year before we finally just moved in for good."

"So you're telling me that none of the Republic's bad reputation is earned? That all of it is made up? Why would anyone just make up bad things to say about the place?" I knew that this place wasn't the intolerant horror I'd expected, but I doubted the reputation was entirely unearned.

"I didn't say that. Currier and Ives isn't for everyone, and we make no bones about it. But some people think everyplace should be for everyone, so they don't like us much. And then they start inventing nonsense about us, like that our law book is as long as an encyclopedia and silly stuff like that. Shoot, our official law code is shorter than the rule book they hand out to people when they move to Luna City."

We rounded a corner, topped a ridge, then the view opened out beneath us. I could see the steeple of the little town church, and Main Street, gaily decorated in her Christmas best. A little band was out on the sidewalk playing *White Christmas*. There were bows on the lampposts and a big crèche to welcome you into town, and folks were hustling and bustling about with packages. I thought this was a pretty neat display for the tourists, but then I remembered that there weren't any tourists around, and for that matter, everyone there knew a nuclear bomb was set to go off in less than twenty-four hours.

What the hell was wrong with these people, carrying on like everything was normal?

"We're going to have our meeting in the church basement," Jo said, "because the Town Hall is being made ready for the annual whole-town Christmas concert. Besides, we shouldn't need all that much room. I only asked people to come who grew up with Manny or knew him pretty good before he was booted out. I don't know if this is going to help you at all, Jake. But at

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least you'll get to see the town while its all decorated up for Christmas."

"How can you be so casual about this? And those people scurrying about? You're right, there was no panic when you told them about the bomb, but I've just never encountered this kind of behavior from people before."

"Sure you have," Jo said. "You just haven't encountered it from a whole *lot* of people all at the same time. The typical Currier and Ives citizen is pretty level-headed to begin with."

"But they're acting like fatalists. 'Whatever's going to happen is going to happen.'"

"There's no sense in 'doing something' just to do something if it won't help. You'll understand better once you talk to some of them at the meeting."

It had been a beautiful morning, but now as we came down the slope into town I could see a storm front starting to move in. Still, at that moment we were in sunshine and under other circumstances it would have been a glorious glide down to Main Street.

The town was something right out of the 1800s, with wooden sidewalks lining a cobblestone street, the cobblestones betrayed by a few red patches temporarily free of snow. People waved to us; children were playing tag, slipping and sliding about in an empty field; and the stores were busy with last-minute shoppers. Even in Currier and Ives, some people wait until the last minute (but then, they didn't have a two-month Christmas shopping season like the rest of the Solar Union).

Seeing the kids playing tweaked a part of me, just a twinge in my heart, not of a bad memory from my youth, but of a good one. I complained earlier about Christmas presents at the orphanage not matching up to those that other kids at school had, but Christmas itself had always been a happy time for us, and I, too, had played tag with the other kids (though in Arizona, not in the snow). My mind continued to wander as I thought about growing up, joining the Patrol, doing my twenty years but somehow knowing that was enough. But I didn't know what else to do with myself so I kept working as an investigator for the Patrol, but as a civilian. I made more money that way, but I was marking time.

We tied up the horses outside the church and went inside. We hung our coats on wooden hangers and proceeded into the basement. There was one folding table set up, surrounded by folding chairs, of which five of the twelve had people sitting in them.

Jo made the introductions. "Everyone, this is Jake Morgan from the System Patrol. You all know why he's here. Jake, these are the folks who knew Manny the best. That's Wilma and Mary there on the left." Two older women nodded their heads at me. "They were his teachers at school. And that young man is Tim. They were on the hockey team together. And these last two are Reverend McMaster and his wife."

The Reverend rose at that point and came to shake my hand. "We're so glad to have you join us, Mr. Morgan. We wish it could be under better circumstances. You're welcome to join

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us for Christmas services tomorrow morning, um, assuming we're able to hold them as planned." He had a firm grip. I liked that.

"Let's get this going," Jo said. "We all know how hopeless Jake's mission is likely to be—no use pretending our chances of finding that bomb are better than one shot out of a thousand. We don't have enough time, the bomb is small and could be anywhere, and so far, we don't have anyone who even claims to have seen old Manny around here the past few days."

I had a few official words I had to say, so I got those out of the way. "What Governor Wood says is correct. I have to convey the deepest regrets of the System Patrol that your community has been put into this danger by someone who wasn't mentally competent to have access to such weaponry."

"That's OK, Mr. Morgan," Wilma said. "We didn't know Manny was going to rape anyone until he did it, either."

"Oh, Wilma, rape is too strong a word," Mary interrupted. "Olivia went from twelve to twenty in one summer and she's the one who asked Manny to help her get those eggs from the chicken coop."

"Yes, but they 'cracked a few,' and he should have known bet—"

"I think Jake has already been informed on the circumstances of what led Manfred to be deported from Currier and Ives," the Reverend said.

Well, yes I had, but not quite at this level of detail.

"That's right," I said. "What I'm hoping to learn from you is something that might, just might, help us figure out where Manfred would most likely have left the bomb. He had reason to dislike Buck Black, for instance, though he says neither he nor, uh, Olivia saw him come down their way."

"And he wouldn't have had to come all that close with a twelve kiloton yield," Tim pointed out.

"There is that," I acknowledged. "But can any of you tell me what Manfred was like? I mean, before he was sent away?"

"Smart boy," Wilma said. "Very, very bright. He could read before he started kindergarten, and the first day of school he insisted on trying to show me he could count to a thousand. I wouldn't let him, and I remember he got pretty angry at me. Even as a five-year-old he didn't like being told 'no.'"

"I'll have to second the part about him being smart," Mary added. "His term papers as a seventh grader were better than most of the things I got from my seniors. Clear, logical, few spelling errors. But he was a charming boy, too. Always had lots of girls hanging around him. I think it was those big, blue eyes—"

"Oh, *Mary!* You and those eyes of his!" Wilma snorted.

"He *was* the handsomest boy in school in the last ten years," Mary said, defending herself. "You can't deny that."

"Best athlete, too," Tim added. "Mr. Morgan, you don't have to wonder how Manny managed to get into the Patrol, and then into the commandoes. He was put together like an Adonis, he was very intelligent, and no

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one could run faster or throw farther than he could. He was just that sort of one-in-a-million kind of guy that makes it into the elite ranks. But he had his own mind, like Miss Wilma said, and everyone knew you just didn't want to cross him."

"Even as a teacher," Wilma added.

"Why?" I asked. "Did he ever threaten you?"

" 'Threaten?' Oh lordy, no. Oops, sorry, Reverend. No, threats just don't happen here, Mr. Morgan. But Manny had this way of replying to you when you'd upset him, these ironic retorts, that you really couldn't say he'd sassed you, but you knew he was being disrespectful."

"I know what you mean, Wilma," Mary said. "Manny was real big on irony and sarcasm. He could really wield his tongue like a sword."

This was all very interesting and revealing, but I wasn't sure it was getting me any closer to finding that bomb. "Was there any particular place in Currier and Ives that Manny might really have felt animosity toward? Anyplace you can think of that he might really want to make sure he destroyed?"

They all looked at me blankly. Finally, it was Mrs. McMaster who spoke up. "Mr. Morgan, I think the problem we're all having is that we just can't believe that Manny would want to destroy anything in Currier and Ives at all. Up until he was exiled, I don't think anyone thought he'd ever be any trouble. Oh sure, we knew he wanted to leave and see the Solar System, but we never got the impression, or at least, *I* never did, that he wanted to burn his bridges and not come back."

"I agree," Tim said. "He loved it here. He liked to hike along the shore, particularly in the fall. We used to do that a lot as we were growing up. When we were older, he and I and some other friends would camp out by the sea and listen to the surf roll in and watch the stars.

"Something just went wrong inside him, Mr. Morgan. Maybe it was the way his parents died—"

"Now, Tim," McMaster said.

"But it might matter, Reverend," Tim protested. "Manny was never the same after that. That's something *I* know."

"OK, so what happened?" I asked. "I think I should be told."

Jo picked up the story.

"We don't like to talk about it. Basically, it was a murder-suicide. Manny's mom Gloria was dying of brain cancer. There was nothing anyone could do about it. Not just here, either, Jake. Anywhere. And Manny's father had had a stroke a couple years before. He did OK, but everyone knew he wasn't the same. Anyway, after the disease had progressed far enough so Gloria couldn't get out of bed anymore, one day Manny went to school and when he got home the neighbors told him they'd heard two gunshots and his folks were both dead.

"It was really no one's business how a husband and wife decided to draw their lives to a close, but neither of them brought it up to Manny. Some of us think his father was supposed to at least leave a note, but probably forgot."

"Yeah. Manny was never the same after that," Tim added. "He didn't want to live in his house anymore.

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That's why he moved in with the Blacks."

The meeting went on for another hour, but no more useful information came out. The most pertinent thing said in that last hour was by the minister: "Mr. Morgan, regardless of what happens, no one will blame the Patrol."

That was nice, but hardly helpful.

Tim agreed to take me around Currier and Ives and show me some of the places he and Manny and many of the other boys used to hang out. I doubted it would help, but I wanted time to think, and Jo had some official work to take care of that afternoon, too. ("Gotta play Santa at the old folks' home," she said.)

Tim had a one-horse sledge. We set out for a nearby hill. We chatted along the way. He wanted to know about space and life on the Moon, so I filled him in with one part of my brain while the rest tried to figure out what the hell Manfred Rolff had in mind when he'd left the bomb here. *If* he'd left the bomb here. That was another question. No one had seen him, anywhere. We had no idea where in the thousands of square kilometers of Currier and Ives he might have left the thing, or if he'd just made it all up for the hell of it.

"Now we have to climb, Mr. Morgan," Tim said, reigning the horse to a stop.

Thank God they kept Luna City at one standard *g*. The climb was steep and we went up for at least fifty meters. If I'd only been used to Moon gravity and had just done a quick tone-up before coming to Earth, I wouldn't have made it up a tenth of the way.

It was well worth the climb.

The top of the hill was a large plateau, surprisingly open, with large, flat sheets of rocks broken and scattered about, surrounded by trees and bushes growing up high along the sides, bursting through the snow. You could see the ocean from there, and the town, and at night I'm sure you could see to the end of the Universe.

"Lots of us boys used to come up here just to kill an afternoon. We'd build a fire, play 'war' there in the trees, kill game to eat. Talk about girls. You didn't have a place like this on the Moon when you were growing up, I'll bet," Tim said.

"I grew up in Arizona. There were lots of places like this." *But I didn't get to go to any of them.*

How could anyone want to destroy such beauty? Even a small part of it? Even if he was mad at the whole world?

I wanted to find that Easter egg in the worst way.

We went to a few other places after that, but those had really been summer haunts, and weren't much worth seeing with snow cover. On the ride back to town I thought about what the outside reaction would be when the bomb went off tomorrow morning. By and large, the Solar Union would just ignore it. There would be some who would think "those intolerant bastards probably deserved it anyway." With shame I realized that I might have been one of them had I been spending Christmas morning by myself when the news broke.

Jo was finished playing Santa Claus by the time Tim brought me back,

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and we went back to her place.

"Why so glum?" Jo asked. "C'mon—it's Christmas Eve. You knew this mission was impossible anyway. Look around you." We were not quite out of town yet. "Do any of these people look like they're going to let this spoil their holiday?"

"But Jo, there is a nuclear bomb set to go off tomorrow morning—"

"Or so was claimed by a psychotic, since deceased, commando."

"We still have to take this seriously."

"We *have* been taking this seriously, Jake. You're here. I've been taking you around, introducing you to the people most likely to be able to tell you something worthwhile about Manfred Rolff, late of the Republic of Currier and Ives, now just late. Assuming he did come here, though no one has seen him, and set a bomb, even at twelve kilotons, what's the worst that can happen?"

"Governor—it's a *nuclear* bomb," I said.

"I know. I used to design those things, remember? Radius of total destruction is a few kilometers, at maximum yield. The radius of serious hurt from the prompt radiation is lots less, so we don't have to worry about that. We might get a little fallout, but the wind blows out to sea around here. If he planted the bomb in one of our towns, then Christmas morning we stand to lose a few hundred people, though probably less than are lost in the typical aircraft disaster. Didn't Luna City lose ninety or so people when that air main broke a couple years ago?"

"OK, OK, I give up," I finally said. But I hadn't. I couldn't really argue with Jo's logic, and in the last twenty-four hours, I couldn't say that I'd gotten any closer to finding the bomb, or even verifying that Manny had really left one here. But even if Jo and the rest of the good citizens of Currier and Ives were willing to wait and see, something wouldn't stop grinding around in my guts.

"I'm going to a Christmas party tonight. You're more than welcome to come," Jo said. "Or, if you wish, you can pack up and leave, though Sarah might be disappointed. Go back to the Moon. You really *have* done more than anyone could have reasonably asked you to do. It's not your fault you can't do the impossible."

"No," I answered. "No, I'm not going to."

"Not going to what? Go to the party or pack up and leave?"

"Sorry. Neither. I decided last night that I'm staying through the morning tomorrow. But I'm not going to the party, either. I'm going to think, *real hard,* and see if something finally comes to me. I just wouldn't feel right if I didn't do that."

"It's up to you," Jo said. "As Governor of Currier and Ives, let me just say, we appreciate it."

Jo left by six that evening, and I was in front of the fire roaring away in the hearth, sitting snugly in the chair, an eggnog within reach.

It was snowing pretty hard outside by the time Jo left, though not blowing around too much—just coming down thick. Jo's Christmas tree was the only source of electric light at the moment,

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apart from the "on" indicator of the entertainment center, which was softly playing Christmas music—"O Holy Night" at the moment.

I started singing along: ". . . Faaallll on your kneeees. All HEAR the angel voi—"

Buzz. Buzz. Buzz. The phone interrupted me.

I answered the call but the screen lit up blank with the "no video" icon. I suppose I should have said "Governor's residence" or something like that, but instead I just said, "Hello."

There was a pause, then: "Is the Governor there?"

"No, she went to a party tonight. I know how to reach her. Do you want to leave a message? Is this an emergency?" That struck me as kind of funny, what with a nuclear bomb set to go off in the next few hours in God only knew which part of the Republic.

"This is that Morgan fella, right? The man from the Patrol?"

"Yes."

"You'll do, then. This is Buck Black. It's about Livvy. She did see Manny. Finally 'fessed up and told me and her husband not ten minutes ago."

I got down to business. Last time I'd met Buck Black, I hadn't even asked any questions. This time was different. I drilled him for all he knew, got him to put Livvy on the line, and then, though I could tell she was trying to keep from crying, got the story out of her.

Manfred Rolff had indeed been to Currier and Ives, and as best as I could figure out, had been captured in Peru not more than five hours after leaving here. Livvy said he'd known where she lived now, knew her husband wasn't home, had just let himself in. She'd gone to put the baby down for a nap and there he was at her kitchen table when she'd come back in the room.

Fact was, though, according to her, nothing at all happened. They talked, mostly about how they'd both changed. He didn't even try anything with her. Then he asked her not to tell anyone he'd been there, and she'd been afraid to say anything anyway because of what others might think even though nothing went on. But then while she, her husband and baby were at Buck's for Christmas Eve, Buck had brought up the bomb, and she knew she had to tell.

I ended the call thinking how nice it would have been to have had this information yesterday when I'd first arrived.

Manny had almost certainly been nowhere else except on the road connecting the tourist spaceport with Livvy's place. Somewhere along the way he would have left the bomb.

That was several kilometers of snow-covered terrain. I looked out the window. And getting more snow-covered by the minute. The wind had picked up and was briskly piling up drifts.

I did a little calculating. Almost all of Currier and Ives was now out of danger. If the bomb went off at maximum . . . Well, the town was safe. Even I was probably safe.

I used the phone again and left a message for the governor, then I called Buck to tell him he'd better get his family into town. Buck said he'd figured that out already and they were already packing. There wasn't any-

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thing else to do. I fixed myself a cider and brandy and sat back down in front of the fire. After a while, I slipped into a fitful sleep.

It wasn't just that sleeping in the chair was uncomfortable, or even that my feet were just a little too close to the fire. Something in my brain had made a connection, and it was trying to fight its way to the surface. This happens to me a lot, though not always when sleeping. Sometimes the connection will emerge if I hike on the mare outside Luna City. When I was a kid I'd hike in the Arizona hills. Sometimes it comes out while I'm eating. But regardless of when the connection finally shows up in my conscious mind, somehow or other I always *know* it's there beforehand.

There was a gyration of images going around in my head. The scenes of Currier and Ives, some real, others no doubt from remembered Christmas cards. Flashes from Christmas movies; the crèche down at the spaceport; an erotic image of two people having sex in a shack (Livvy and Manny, though the man didn't look like Manny, and I had no idea what Livvy looked like). The shiny Easter egg hanging from a lanyard.

A mushroom cloud.

I sat bolt upright, fully awake. It was what Wilma had said. *Broke a few eggs.* Manny and Livvy had broken a few eggs in the chicken coop.

I remembered the crèche, the detail, all the animals carefully emplaced for perfect balanced effect around the manger. There were hens in the back, sitting in their boxes.

This was Currier and Ives. I just knew there were eggs underneath those hens. Manny had loved irony. He'd broken a few eggs in the chicken coop.

Someone would have said that to him. It would have been a local joke. Now he was *really* going to break some eggs.

I had to get to the spaceport. I looked outside. The wind was howling now, driving the snowfall horizontally. And it was after eleven o'clock already.

I couldn't wait for Jo to get back with the sleigh, even if the horses could make it through the storm. I put on my coat and borrowed boots.

More than six kilometers to the spaceport, and I had to do it on foot through a snowstorm. What the hell? I made it down to the road without trouble and trudged along. I had a devil of a time keeping on the road. I couldn't see more than a few meters ahead of me, and to make any headway I had to focus on the snow bank piled up along the side from past plowings.

High gusts raked snow across my face. That would blind me and I'd find the snow bank on my left instead of my right, having wandered across the road. One time it was so bad I thought I might have turned around, but then I found my footprints and knew I hadn't.

I seemed to walk for hours and I was having trouble catching my breath. It was cold.

"God, how much farther?" I yelled into the night.

Heading out into the storm had been stupid. I'd had no idea what a blizzard could be like, how dangerous it could be.

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I knew I was in big trouble when I staggered into a branch and realized I'd wandered off the road and into the woods. I tried to find my footprints to backtrack, slipped, found myself sliding into a shallow ravine.

"Where am I? Jake, you're a fool. You're going to freeze to death on Christmas Eve. Alone."

Unless the bomb went off soon. Then I might be incinerated.

A man confronts himself at such times. I wondered why I'd never married. I'd known enough women. Some of them might have been open to the permanent thing. Sarah's face came to mind. What had my problem been? Fears about winding up like my folks? Why? Like I was a slave to my past, with no hope but of repeating their failure?

I kept walking. It occurred to me that the ravine was probably the little frozen creek I'd seen along parts of the road on the way to Jo's house. I tried to find a place to climb up the bank and look for the road.

At least the wind wasn't as bad in the woods, even though it was darker than on the road.

I trudged along the bank, slowly, fending off snow in my eyes, then finally came to a low spot and was able to get out. I stumbled from tree to tree, saw a flash, lost it again.

A flash?

I backed up and saw the flash again, then found the spot and fixed on it. A light. I'd found a light.

I didn't know where the light was coming from, but it implied power, so I knew it had to be by the road or a house or maybe even the spaceport. Where it was didn't much matter to me just then—I wanted to get out of the snow and cold. My feet had already passed from cold to numb, and my gloves weren't doing the job that demanded thick mittens.

I kept following the light, letting it be my guide, hoping it would lead me to . . . well, the manger scene. Even in the miserable cold I smiled at that thought.

I hadn't found the road after more than ten minutes, but the light was much brighter, forcing the trees to cast shadows, and after a few more minutes I emerged from the woods on the south side of the spaceport. The light was atop a tower near the reception area.

I tried to run across the snow-covered port. I was so worn out and the snow was so deep that I stumbled a dozen times before finally getting to the door.

How to get in?

The door had an old-fashioned doorknob on it, the kind you had to turn. Quaint. I took off my glove and tried to turn the knob, praying it wasn't locked. This was Currier and Ives—there was a good chance it wouldn't be.

The knob wouldn't turn, but then, my hand was so cold it wouldn't work right anyway. I'd never been that cold, never had my fingers refuse to close at my command. I pulled my other glove off with my teeth and tried locking both hands around the knob. I twisted my whole body.

The knob turned, the door opened, I fell inside.

Glorious warmth and freedom from the wind. It was a struggle to pick my-

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self up off the floor. I just wanted to stay there and rest.

I glanced up at the clock on the wall: 0250. I'd been outside *that* long? Shit.

I got up and turned on the lights. It looked like a mile to the back of the room. My feet were starting to warm up, and getting prickly. I staggered twice but I didn't fall down.

Turning the corner, I saw the magnificent Christmas display. Even with the scene's lights off, it was beautiful.

Past the sheep and the goats, I steadied myself on Joseph's shoulder, then lunged to the back of the stable and the first chicken in her roost. I lifted her out. Sure enough—eggs!

All four of them were white. I picked up each but they were just plastic. I turned to the other chicken, just cuffed it out of its roost, knocking it on the floor.

Four more eggs, all white, all plastic.

I walked out of the stable and sat down on one of the rocks a shepherd was kneeling beside.

"All for nothing," I said to him. "I half killed myself out there in the storm—all for nothing. I was so *sure*."

Dejected, exhausted, I decided to rest on my rock for awhile before looking for a phone and calling the governor and telling her I'd found nothing. She was probably still at her party. She wouldn't have wanted to make her horses go out in the storm.

I'd be spending the rest of the night here, I was sure. What a way to celebrate Christmas.

But come to think of it—this was the most meaningful Christmas Eve I'd had in my entire adult life. And this Christmas display was a beautiful place to spend the night. That fake snow bank on the Santa Claus side looked comfortable, right next to the Christmas tree, leaning to the left just a tiny bit more than when I'd first seen it, the only imperfection in the whole display.

"Oh my God!"

No one in Currier and Ives would put up a Christmas tree without making sure it was straight.

I walked up to the tree. White lights, shiny ornaments. Shiny like the Easter egg. I peered deep inside the branches, searching, searching.

The Easter egg's lanyard was twisted around a branch close to the trunk on the left side. I reached in and even though my hand was still numb, I was able to pull it out.

I looked at the timer. It was set to go off in—let's see. It was on Luna time. I did a mental calculation.

"Oh my God," again. I had two minutes to turn it off.

I fumbled the egg in my fingers. My fingers wouldn't work. I couldn't get them to push the shut-off code into the two flush buttons.

I kept trying. One minute left.

"Jake? Jake, are you in here?" The governor.

"Jo! Here!" I shouted, barrelling off the display and around the corner. "I have the bomb. I can't . . . I can't get it to shut off."

Jo met me in the middle of the room. She deftly took the Easter Egg out of my hands, looked at the indicators, entered the code, then nonchalantly swung the egg around on the end of its lanyard. "Twelve seconds to

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go," she said. "Hardly even exciting."

"Maybe not for you," I sighed. "How the hell did you and the horses get here through the storm?"

"What horses? Jake, the sleigh has a repulsor drive. Emergencies happen. Why didn't you say where you were going? I spent the last three hours looking for you in the storm until I finally decided to see if you'd come here." She held out the Easter egg. "Point five KT—lowest setting. And three in the morning. Nice to know Manny didn't want to hurt anybody, no matter what else he had in mind."

"We'll never know what he was thinking." Jo gestured toward the door and we headed for the sleigh. I told her my story. "I was lucky to even make it here. If it hadn't been for the spaceport light, I'd still be out there in the woods."

We stepped outside and Jo gave me a peculiar look. "What light? There aren't any lights on out here."

"But it's right up—" I looked up at the light tower. The light was off. "But it was on, Jo. It was *on*."

"Hmph," she said. "Well, maybe it was a miracle. It's Christmas, you know."

"But—"

Jo started laughing. "Oh, Jake. You should see your face! Gotcha! I shut the light off when I came in. It's on automatic. It always comes on at night unless it's overridden."

We climbed onto the sleigh. "I want to go to Christmas dinner with you today," I said.

* * *

I went straight to bed when we got back to Jo's, but still awoke with first light, fully refreshed and rested. Jo had already contacted the Patrol, but I thought I'd better call Mark's office and leave him a message before we went to the Christmas service at church and then Sarah's. But when I called I was routed straight to his home where I could see his wife and two delighted kids in the background playing with toys around a Christmas tree.

"Jake! Great job! And we thought it was hopeless. Finding that bomb was a real Christmas miracle," Mark said before I could get a word out.

"No, Mark. Just some real good luck and putting the pieces together."

"You're too modest, Jake. Want me to send the shuttle for you? We can have you back on Luna by tonight."

"Nope. I'm on vacation, remember? I'm going to dinner today, and I'll let you know some time next week when I'm coming back. But I gotta run. Merry Christmas, Mark."

"Merry Christmas, Jake."

The storm was over and the Sun was shining when we set out, this time with Mary Lou and Nellie Sue. Jo had added sleigh bells to their harnesses. I thought about the dinner we'd be having soon, the eggnog, and taking Sarah aside to tell her about life on the Moon.

The spaceport light hadn't been a miracle, nor had been finding the Easter egg at the last minute. Still, a miracle, a small one, had occurred.

I could feel it inside of me. ■

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IT'S ANLAB TIME AGAIN

YOUR BALLOT WILL BE AUTOMATICALLY ENTERED IN OUR DRAWING FOR A FREE ONE-YEAR SUBSCRIPTION!

December is our last issue for 1997, and as usual we're asking you to help us via the Analytical Laboratory. Not only will your votes provide tangible awards for your favorite authors and artist, but your feedback will help guide our selections of what to offer you in the future. Your vote is important!

Look over all your copies of *Analog* dated 1997, or refer to the annual index which will appear in our January 1998 issue. Pick your *three* favorites in each of the following categories: novella, novelette, short story, science fact article, and cover. If you're not sure about a piece's category, you'll find it listed in the Table of Contents for the issue in which it appeared, as well as in the Index. In the event of a disagreement between the Table of Contents and the Index, the Index should be considered correct. List your choices in order of preference (your favorite in each category is #1) on the ballot below, and either mail it in or send it e-mail. The ballot is intended to make it easier for you to vote, but if you don't want to cut it out, feel free to copy it.

To be sure your vote counts, please have it reach us by **February 2nd, 1998.**

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Steve Hockensmith

ARNOLD THE CONQUEROR

Trying to govern an interstellar empire is a bit like governing a transoceanic empire in the days of sail—with at least one important difference!

Arnold Amlingmeyer wanted a bridge to stride across, a control room to dominate with his sinister presence. But he didn't have one. The *Rectifier* was far too cramped a ship for such a luxury, and everything was automated anyway. So he had to content himself with striding down the narrow hallways and dominating the sleepchambers. It worked well enough. He just needed the practice.

Eventually, after almost an hour of striding and dominating, he felt powerful enough to begin waking up his men. Sgt. Winslow "Bull" Schott came first. Schott was the professional, the one who would handle the military side of the operation. But he would be taking his orders from Arnold.

Arnold and Schott hadn't met yet—the Marines had boarded and gone into hibernation almost a week before Arnold was picked to command the mission—so Arnold thought it was important to impress Schott the second he woke up. He hovered over the soldier's sleeptube while the central computer brought him out of hibernation.

He agonized over his opening line. "Arise, my pawn," seemed overblown. But "Get up and get ready to kick some mother-lovin' ass!" didn't have the right kind of grave dignity.

The shieldglass over Schott slid away. The soldier's eyelids were flut-

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tering. Arnold leaned down over him.

"Good morning, Sgt. Schott," Arnold intoned menacingly. "It's time to wake up and crush a rebellion."

Schott groaned. "Wha'?"

"It's time to wake up and crush a rebellion!"

The sergeant's eyes opened. He stared up at Arnold, disoriented. "What did you say?" he mumbled, his voice slurred by years of sleep.

Arnold suppressed the urge to sigh. "Sgt. Schott, I am Ulysses S. Rook. I am in command of this mission. It's time to get your men ready. We're only a day away from Sigma Draconis IV."

Schott rubbed his eyes groggily. "Sigma what? I thought we were going to New Venture."

Arnold clinched his fists. "Yes, that's right, Sergeant. They're the same thing." He whirled around and began using his newly perfected stride. "Get the troops ready. I'm contacting the rebels tomorrow."

"Excuse me?"

Arnold kept striding.

Arnold spent most of the next day in his cramped chamber, hiding—although he preferred to think of it as "lurking." He was still trying to cultivate an air of refined menace, but he wasn't sure if it was working. The soldiers didn't seem to fear him yet. He needed more practice.

Schott came to him every few hours with updates.

"The T-11s are locked down," was one report. Arnold didn't know if this was good or bad, so he just nodded curtly.

"The A.S.C. triple-naughts are primed and ready for action," was the next update. That had to be positive, so Arnold smiled ominously. "*Ex*-cellent," he hissed.

"The scheiss gun has been willowed and boundered," Schott told him an hour later. "And the putz tubes are ready for planking."

The soldier stared at Arnold. He seemed to expect some specific response this time. "By all means, plank away, Sgt. Schott. We can't have unplanked tubes, can we?"

Schott smiled at that. "No, sir." He saluted ostentatiously, turned crisply on his heel, and left.

The sergeant treated him with cool deference, which was satisfying. But Arnold had been hoping to inspire craven cowering in his underlings. Schott didn't seem like the kind of man who did much cowering, though. He was easily six and a half feet tall, with steel-gray hair and hard eyes. Arnold had asked Schott to refer to him as "Commander Rook"—he'd picked out the name for its diabolical flair—but the soldier got around the order by simply calling him "sir." That was good enough for Arnold.

Trying to impress Bull Schott and the troops had just been a warm-up, though. The people Arnold really needed to make an impression on were the rebels—the colonists of New Venture.

Thirty-four years ago, Omnicorp had received the first empty transport ship from its colony eighteen light-years away. The only cargo had been a single message disk. "As of this moment, the citizens of New Venture declare the Colonial Licensing Charter

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of 2116 to be null and void. We proclaim ourselves free from indenture to Omnicorp and all contractual obligations to same," said the young woman on the disk, who identified herself as "President Yeo." "We're sorry it came to this. But obviously, our relationship had become pretty one-sided. We gave, you took. It's best if it ends this way." The woman smiled sweetly. "We can still be friends, can't we? Good-bye."

Still be friends? When New Venture owed Omnicorp 755 tons of iron, 467 tons of lead, 355 tons of copper, 301 tons of gold, 287 tons of silver, 212 tons of cobalt, 23 tons of deuterium, 14 tons of uranium, 13 tons of plutonium, 2 tons of diamonds and other precious stones, 987 samples of native flora and 546 samples of native fauna? Not to mention assorted penalties and fees now that was decades late. Arnold could figure it all up in his head. He'd come up through the Accounting and Finance division, after all.

Obviously, Omnicorp had to do something. If it didn't act decisively, its days as a colonial powerhouse were over. Someone would have to go to New Venture to restore order. A company man. The ultimate company man.

Arnold still wasn't really sure why they'd picked him. Maybe it was because he was one of the few candidates who really *wanted* to go.

It didn't bother him that he would never see Earth again. He wasn't leaving much behind. His sister, his mother, and his fish might miss him. No one else would. New Venture was a desolate, sparsely populated rock, but what he would have there would be endlessly more satisfying than anything he had back home: power.

He'd been picked out of obscurity for the assignment: He wasn't a corporate star, not even a "go-getter" in most colleague's eyes. But somehow Omnicorp's decision hadn't surprised him. He believed in destiny. He had always known that one day he would be a mighty figure of fear, that people would tremble before him. It had only been a matter of time before the Universe revealed the circumstances.

And now fate had deposited him on his own starship (actually a hastily refitted cargo barge once known as the *Omnicorp New Jersey*) complete with a platoon of fierce Marines (mostly debtors, petty criminals, and other conscripts, but they would soon prove themselves in battle), two powerful nuclear warheads (a couple of army-surplus Pocket Nukes), and the prerogative to use them as he saw fit.

Arnold clasped his hands behind his back. "*Ex*-cellent," he said.

It sounded good, so he said it again.

Arnold had options. He could use one of the Pocket Nukes to announce his arrival. He could send down the Marines. Or he could hold off on the muscle until he'd gauged the rebels' attitudes.

It was an easy choice. Pocket Nukes were expensive and—now that he was so far away from Earth—hard to come by. And though Bull Schott seemed capable enough, his troops were untested.

Negotiating first would give Arnold a chance to put his personal powers to the test. Could he intimidate the

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colonists into abject capitulation? Would they recognize and fear his authority, his ruthlessness? He had to find out.

He draped an Omnicorp flag on the back wall of his chamber and brought in Schott and two Marines to stand before it. Then he squeezed in front of them—it was a tight fit—straightened his jet-black tunic, cleared his throat and switched on the communi-unit.

"People of New Venture, the time of reckoning is at hand. I am Commander Ulysses S. Rook of the starship *Rectifier*. I have been sent by Omnicorp to restore the rule of law and collect payment past due. I have at my disposal both a nuclear arsenal and a full battalion of Earth's finest fighting forces. I am more than willing to employ these resources to devastating effect. You are powerless to stop me. If your leaders do not signal to me their complete and utter surrender within three hours, I will destroy Venture City and send down my troops to take control of the planet. Your rebellion is at an end. Do not be so foolish as to test my resolve."

He switched the communi-unit off and turned to Schott.

"What do you think, Sgt. Schott? Will they give in . . . or will we have to crush them beneath our bootheels?"

"Sir, I think—" He looked over Arnold's shoulder. "I think you have a message," he said. He looked thankful for the interruption.

"Incoming" flashed across the screen of Arnold's communi-unit. "This is Rook," Arnold said.

A dark-skinned woman appeared on the screen. "I am Helen Bozyk, president of New Venture. There's no need for violence. We surrender."

Arnold let a prim smile crease his lips. "Good. You have chosen wisely. But as of this moment, you are no longer president of anything. I am now the military governor of New Venture. I will come to Venture City immediately to begin organizing the next shipment to Omnicorp. See that there is no resistance. If a single shot is fired against us, the full nuclear capabilities of this vessel will be unleashed on your population. Is that clear?"

Bozyk nodded. "Yes. I understand."

Arnold turned the communi-unit off again.

"That was quick," Schott said.

"They're not fools, Sergeant. They could see I'm not to be trifled with."

Schott considered his reply for a moment. "Should we prepare the shuttle? With an escort?"

"Of course, Sgt. Schott. I'd like to inspect my new capital as soon as possible."

Arnold dismissed the soldiers and slid open his closet. He'd had a duraleather field uniform custom-made back on Earth. It had cost him a fortune, but what difference did it make how much money was left in a bank account eighteen light-years away? The people of New Venture were about to meet their new ruler. They deserved a spectacle.

Arnold was sweating under the hot light of Sigma Draconis. His field uniform looked impressive—he'd spent a full hour strapping on his gun belt, adjusting his epaulets, puffing out his

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breeches, pinning on his medals, tilting his busby just so. But the fabric didn't breathe. It was stifling. He was almost afraid he would faint.

He struggled to conceal his discomfort. There were the throngs to think about. The *cheering* throngs.

Thousands of Venturians lined the streets, greeting Arnold and his motorcade with hurrahs and confetti. Some of them even waved little flags, though Arnold couldn't see from his touring car what kind of flags they were. Occasionally, a girl would dart into the street to kiss one of Arnold's Marines. An old woman tossed him a bouquet of flowers.

They weren't just conquerors. They were liberators! Although liberators from what, Arnold wasn't sure. Most likely Bozyk was a tyrant, her cronies radical anti-corporationists. The people were thrilled to be returning to the womb of civilized mercantilism.

Arnold waved to the multitudes—a reserved wave, the bent-elbow handflutter of pontiffs and royalty.

"Shouldn't you sit down, sir?" Schott growled. The grizzled old vet's eyes scanned the crowd anxiously. "You make a good target standing up like that."

Arnold kept his eyes on the crowd, too. "I don't think we have anything to worry about," he said, waving. "Look at those faces! We're heroes, Sgt. Schott. No one will try to harm us." He gave a lump in his tunic a quick pat. "But even if they are foolish enough to oppose us, we've got the Pocket Nukes to back us up. One push of a button, and the *Rectifier* will unleash fiery death from above."

Schott simply grunted in reply. Arnold let the lapse in protocol slip by.

A few minutes later the motorcade reached the capitol building. A somber delegation of Venturians was waiting on the steps in front. Bozyk was among them. She stepped forward and bowed solemnly.

"Commander Rook, welcome to Venture City."

Arnold's driver hopped out and opened the back door of the touring car. Arnold stepped down from the vehicle with regal confidence.

"Thank you, Citizen Bozyk. Your cooperation so far has stayed your execution. Continue to cooperate, and it may be delayed indefinitely."

Bozyk lifted her head. Her eyes were calm. "I understand, Commander."

"Good. Now please show me to your office—or I should say *my* office. I have much to do and I wish to get started immediately."

Bozyk bowed again quickly. "Certainly, Commander. This way."

Arnold marched crisply up the steps after Bozyk. Schott came, too, waving a handful of Marines to follow. More Venturians were waiting in the lobby as Arnold and his party entered. They all bowed silently.

Bozyk led them to an ornately decorated elevator bank. "This leads directly to your office, Commander Rook," she said.

Emblazoned on the elevator doors was a huge "R" in a golden crest. It looked remarkably like the insignia on his own uniform.

Arnold chuckled dryly. "Ironic. What did the 'R' on these doors originally stand for?"

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"The 'R' is for 'Rook,' Commander," Bozyk replied.

Arnold raised an eyebrow at Schott. The sergeant didn't seem amused. "Your people do quick work, Citizen Bozyk."

Bozyk smiled. "Thank you, Commander."

The doors opened, and Bozyk motioned for Arnold to enter.

"After you, Citizen."

Bozyk stepped into the elevator. Arnold waited a few seconds. Seeing that no laser beams or bullets or metal rods had torn Bozyk to pieces, he followed. Schott stepped in after posting more guards in the lobby. The doors closed and the elevator began to hum.

"I think you'll like your office, Commander," Bozyk said. "We did our best to please you."

The doors slid apart, revealing a room straight out of Arnold's dreams. The desk was vast, easily the length of a luxury groundcar. The gold-crested "R" shone from its black durawood. On each side of the desk was a globe—one of Earth, one of New Venture. Behind it was a long picture window looking out over the city. On the opposite wall was a larger-than-life portrait of Arnold himself. He stood on a rocky precipice, hands on his hips, his face bathed in the glow of Sigma Draconis.

Bozyk stepped up to the picture. "We can redo the painting if you wish. We weren't sure which of your uniforms you would prefer."

The portrait showed Arnold in his field uniform—which he'd put on for the first time just hours before.

Arnold walked over to the massive desk and leaned against its smooth, cold surface. Once again, he was afraid he might faint.

"No, it's fine," he said, his voice a whisper. "How did you finish all this so quickly?"

"We didn't, Mr. Amlingmeyer. We've been preparing for you for years."

Arnold straightened up and turned to face Bozyk. "I am Ulysses S. Rook, commander of the starship *Rectifier*!"

Bozyk nodded. "Yes, you are now. But back on Earth you were Arnold Amlingmeyer, certified public accountant of Queens, New York."

A harsh laugh boomed out, bouncing off the walls of the cavernous office. It was Schott. "I knew it!" he said. "I knew it!"

"That will be all, Sergeant!" Arnold snapped.

Schott stopped laughing, but the look of bemused contempt didn't leave his face.

Arnold turned back to Bozyk, trying to burn into her with a malevolent gaze. "Where did you get your information? Anti-corporationist spies?"

"Spies, yes. The corporate kind," Bozyk replied, unruffled. "Omnicorp's rivals were more than happy to help us. Their radio reports reached us a lot faster than your ship could. We've had your psychological profile for almost twelve years. We have files on all your men." She favored Schott with a smile. "Even you, Bull."

"None of that changes anything," Arnold replied, straining to sound icy cool. "My troops have occupied the capital, and I am taking control of New Venture."

"Your troops are *in* the capital, but

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I'm not so sure they're *occupying* it anymore."

"What do you mean?"

Bozyk stepped over to the picture window. She gestured at a large estate visible below. In the center of a long, immaculate lawn stood a massive, pillared palace. The "R" crest glinted in the sun above the front steps. Dozens of smaller yet equally pristine houses ringed the estate.

"By now, most of your 'Marines' on New Venture have been told about their new homes." Bozyk pointed to one particularly ornate house surrounded by a small grove of drooping trees. "That one's yours, Bull, if you want it. Does it look familiar? We modeled it after the commandant's quarters at Fort Eisner. You always admired that house, didn't you?"

Schott rubbed his chin. "It looks a hell of a lot nicer than a barracks, that's for sure."

Arnold could see figures—many of them clad in olive drab—moving up and down the streets between the homes. "I want a status report, Sgt. Schott."

Schott turned around slowly. From the look on his face, Arnold couldn't tell if he was going to speak or spit.

"O.K., *sir*," Schott said. He flicked on his helmet mike. "Feiffer. Feiffer, report. Feiffer! Damas. Damas, are you there? Goldberg, check in. Goldberg?" He shook his head. "Sorry, *sir*."

"Now you understand your hero's welcome," Bozyk said to Arnold. "You are our savior—from Omnicorp. All you have to do is join us and become a revered citizen of New Venture."

Schott waggled a thumb over his shoulder. "You built all that for us?"

Bozyk nodded. "Yes. It was expensive, but cheaper than our freedom . . . or who knows how many lives."

Schott grunted.

Arnold knew he'd lost him. He was losing all his men, all his power. But he still had his Pocket Nukes—and his nerves of steel. He worked up a sneer.

"It's a trap, Sgt. Schott. You're a fool if you can't see that," Arnold said. He slid his compad out of his field jacket. "Fortunately, I don't need the help of fools to subdue this planet. The nuclear devastation I hold at my fingertips is all the help I need."

Bozyk's cool facade finally cracked. "Please, no!"

Schott swung his rifle off his shoulder—and pointed it at Arnold. "Don't do it, Amlingmeyer."

Arnold let his thumb caress the firing key. "The name is Rook. And I don't take orders from mutinous sergeants."

Bozyk took a wobbly step towards Arnold. "Please, you have to believe me. It's not a trap," she said, her voice trembling.

"Perhaps you could convince me of that. But it really doesn't matter if it's a trap or not," Arnold replied. "You must submit to my authority . . . or watch half your population vaporized."

"You wouldn't!" Schott spat.

Arnold returned the soldier's scornful gaze. He held it for a long moment until . . . There! He saw it! *Fear*.

"Push that button and I'll blow your damn head off," Schott said. His words came out too loud and fast and shrill to hide his fright. "I mean it! I'll kill you!"

Arnold looked back at Bozyk. She

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had dropped to her knees. She was pleading with him.

"I beg you, have mercy," she said. "Have mercy on us, Commander Rook."

Arnold drank in the raw dread on her face, savoring it. This was the moment he'd always dreamed of. This was his destiny!

He was satisfied.

New Venture was always fond of its "dictator." The citizens bowed to him as he paraded down the streets of the capital. He got the best seat in any restaurant or tavern he entered, and the food and drink didn't stop coming until he was completely satisfied. Merchants competed for the honor of supplying him with free goods and services. Most fierce of all was the competition over his clothes. Every tailor and would-be designer on the planet wanted to claim credit for Commander Rook's uniforms, which he updated every spring.

The government treated him with deference, too. He opened every session of parliament (after a grand entrance and a short speech) with the whack of a ceremonial gavel. And he received private briefings from the presidents—first Bozyk, then Mendelsohn, then Schott.

"*Ex*-cellent," he would say at some bit of news. Or "You have done well." Or "I am pleased." Or he would just nod and look thoughtful.

Sometimes he would offer advice, but as the years went by only the complex haggling over the state budget really interested him. Occasionally his ideas were even good.

Not every Venturian treated him with respect, of course. Some couldn't conceal their derisive grins. They would snicker or make sarcastic comments in his presence.

But his grave, dignified mien never faltered. He would just go a little glassy-eyed, as if he no longer saw the people around him but was instead looking at something that had happened long ago, something infinitely more important. Sometimes he would pat the empty pocket of his uniform tunic or rub his thumb slowly over his forefinger, as if stroking some invisible key. Then he would smile his prim little smile and return to the palace. ■

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Probability Zero

The Cure

Michael A. Burstein

The machine looked like something out of a 1950s B movie, with blinking lights, metal rods, and the occasional electric spark, but the doctors had assured Adam that it would work. He took one last look at the machine, and then the nurse directed him to the platform bed in the middle.

Adam lay down upon the bed, feeling cold in the thin hospital robe. The nurse began methodically strapping Adam down, first fastening straps at his wrists and then at his ankles. Next she inserted needles in his arms, connected to tubes that led out of sight. Finally, she fitted a helmet onto Adam's shaven head. Metal electrodes, cold to the touch, affixed themselves in a ring all around his crown.

"All set?" Adam asked.

The nurse smiled. "Just try to relax, Mr. Gantz. We'll be ready in a minute." She walked away.

Adam twitched his fingers and wiggled his toes, uncomfortable at the lack of mobility. But still, this sacrifice, like all others he had made re-

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cently, was well worth it. That is, if the machine would do what he was promised it could. As he lay there, he thought back to his appointment one month ago that had led to this moment.

"Yes, Mr. Gantz," the doctor had said, putting him at ease. "All of us here at the Lycanthropy Institute truly believe that your condition exists, and we have in fact developed a method to cure it."

"You're telling the truth? I won't be a werewolf anymore?"

"Well, Mr. Gantz, in all honesty, we don't know if the method will work on everyone. Basically, we have located a major gene group that seems to be the one that leads to lycanthropy. What we do is act upon the gene, neutralizing it so that your cells won't attempt to express it anymore.

"But," the doctor cautioned, "our method is very new and very experimental. We don't know if your particular brand of lycanthropy is—"

"Never mind that," Adam interrupted. "Has it worked on others?"

"Yes. Ever since we started L.I. last year, over a hundred people have come to us to be cured."

"And?"

The doctor smiled benignly. "And they have all been cured successfully."

Adam had signed up for the treatment immediately. For too many years he had lived with the pain and burden of his monthly cycle. He still remembered the first time he came out of his werewolf stage, when he had just turned eighteen, his clothing in tatters and blood on his mouth and hands. They had never traced the disappearance of the Barrett girl to him, but he had been plagued with guilt for months afterwards.

Since then, he had made sure to stay indoors on the night of the full moon, locked in a closet or handcuffed to a bed. It didn't always work, though, and Adam had resigned himself to the damage he would do the world in his wolf phase. It wasn't as if he could control himself, after all.

But now there was a chance for him to be free of what Nature had forced upon him.

Adam's reverie was interrupted by the doctor's voice, coming over a tinny intercom. "Are you ready?"

"Yes," Adam replied.

"Then we shall begin."

Adam heard the clank of a large switch. A jolt of electricity surged through him, and he felt fluids seep into his body from the tubes.

After a minute, he felt a tingling, unlike any he had felt before. His skin and bones felt like they were stretching. Was that it? Was he stabilizing into his human form? Was he—

Sudden pain! Adam twisted himself against the restraints. He tried to scream as loudly as he could, but no sound came out. He whimpered instead.

What was happening to him?

"Well?" asked the doctor.

"The treatment is complete. Mr. Gantz is cured."

"Excellent. Call the ASPCA, and tell them we have another stray wolf for them to put to sleep." ■

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Frederik Pohl

Best-laid plans may go agley, but how bad that is depends on who you ask. . . .

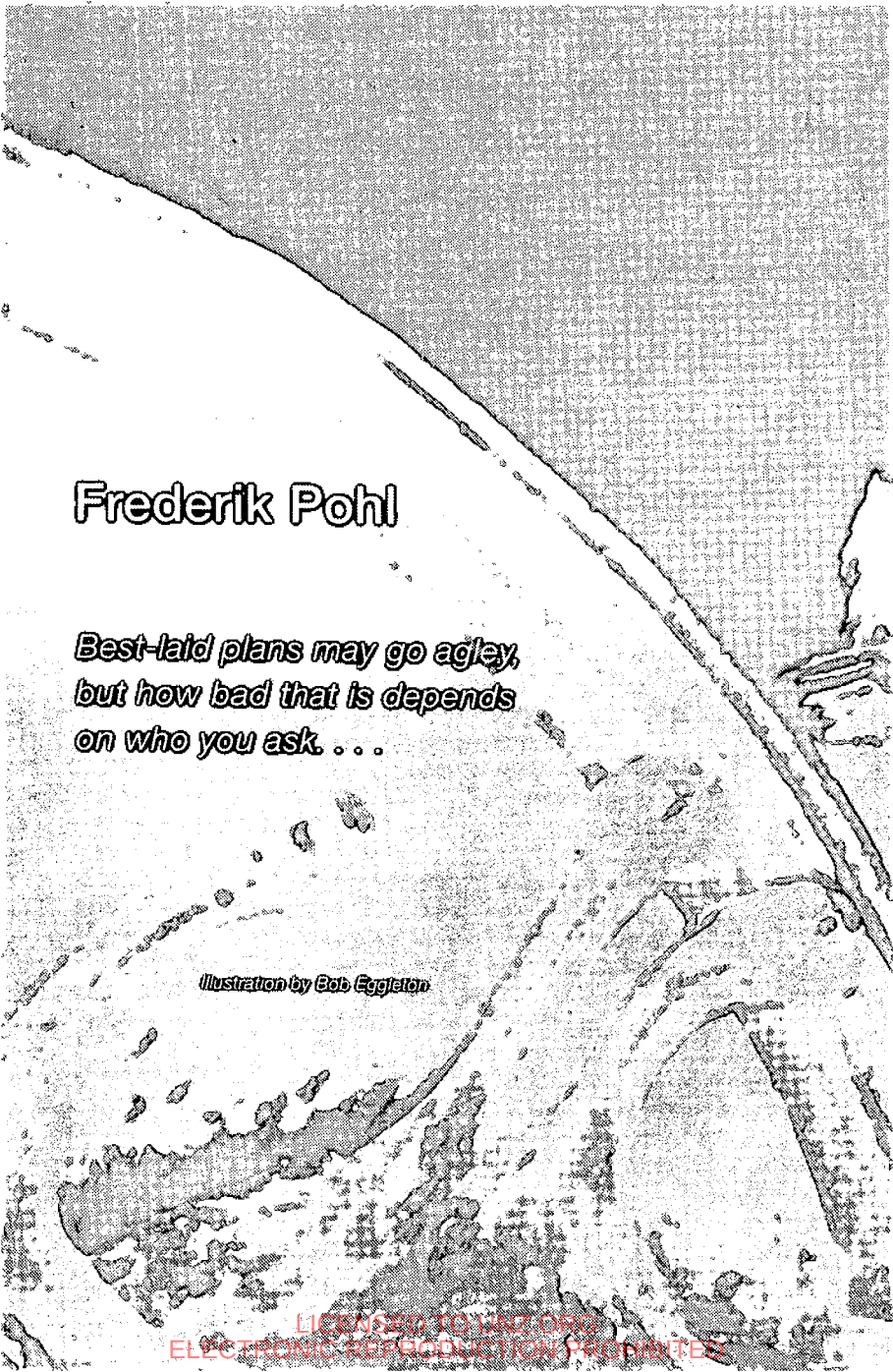

Illustration by Bob Eggleton

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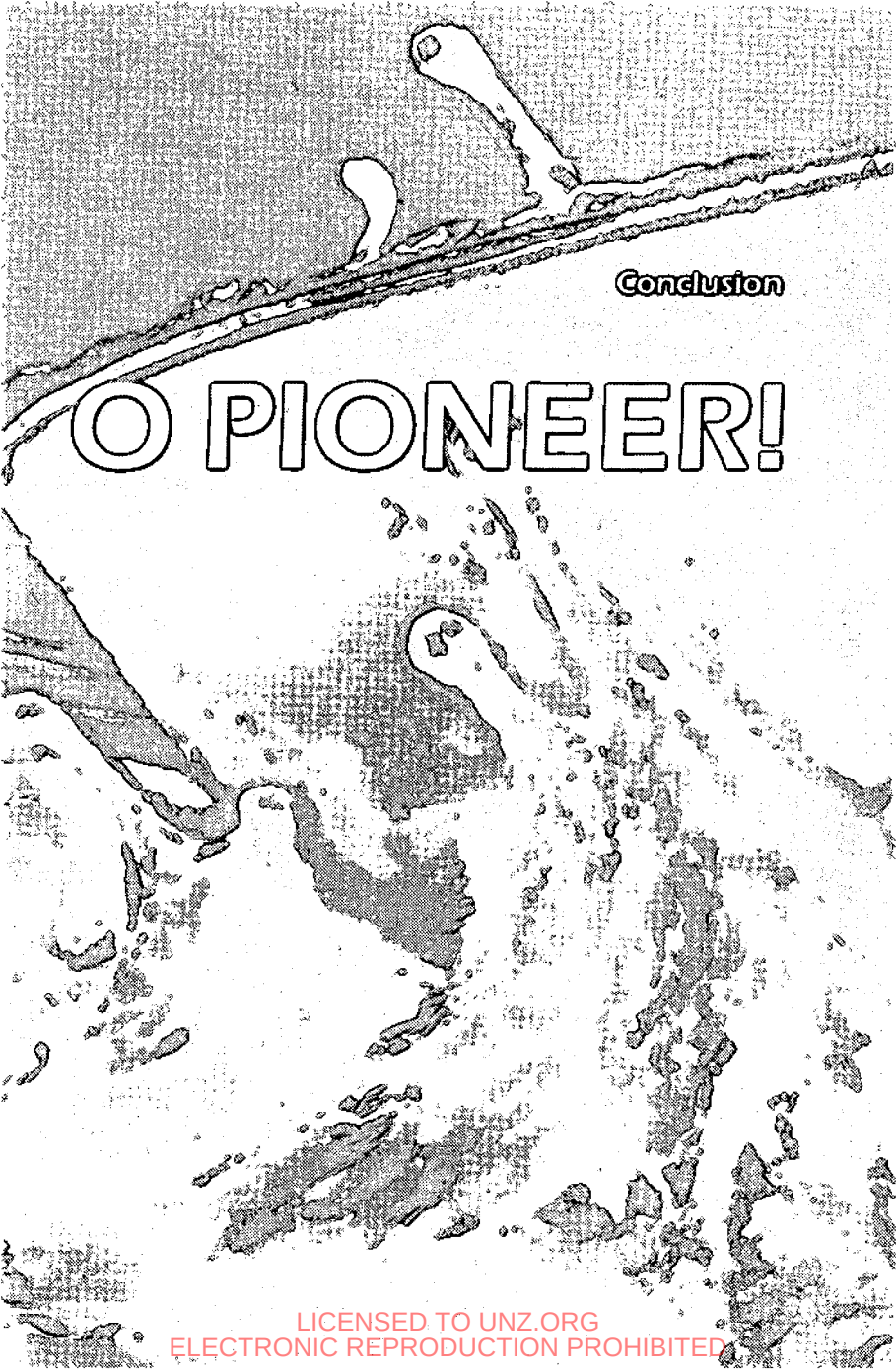

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SYNOPSIS

For Evesham Giyt life in the low-rent district of Wichita, Kansas, was easy. Because he was good, maybe the best in the world—at teasing into any computer datafiles whatever data he wanted them to hold—he had plenty of money, no responsibilities, and plenty of time to indulge his personal interests, of which he basically had two. One was daydreaming about famous conquistadors of the past, whose lives were so much more exciting than his own. The other was his lover, Rina. The fact that Rina had once been a prostitute didn't bother him; she had retired from that line of work long since and was currently taking business-management courses at the local campus of the University of Kansas. The only thing that really bothered Giyt was that Earth was fully explored. It had no new lands left for a person like Giyt to conquer—even if he had been actually willing to do any conquering, which he wasn't. Conquering generally involved a lot of killing. The last thing Evesham Giyt ever wanted was to kill anybody.

What changed Giyt's life was that he met a recruiter for the planet Tupelo.

Tupelo was by all means the nicest planet Earth's astronomers or interstellar probes had ever discovered. It had Earth-like air, climate, and gravity. Maybe it was a little short on land area—the planet was basically all ocean, apart from one fairly puny continental landmass at its pole and a scattering of islands—but, taken all in all, it was eminently suitable for colonization.

It did have one minor drawback. Five separate species of extraterrestrial aliens were colonizing it already.

However, that wasn't a big problem. The aliens were willing enough to let Earth humans immigrate as well. What was more, the Extra-Earth Foundation—Ex-Earth for short—was prepared to subsidize any would-be colonists. Getting to the planet was no problem, either. You stepped in one door and stepped out another, thanks to the amazing Sommermen FTL transport system.

It seemed to be just what Giyt wanted. He signed up at once and, with Rina by his side, took the plunge.

The planet Tupelo turned out to be just about as attractive as the recruiter had promised. Rina quickly made friends with their next-door neighbors, the same-sex couple of Mrs. and Mrs. de Mir and their brood of children, while Giyt's computer skills fit right in with the needs of the little Earth colony. When he had reworked the budget systems so they could function efficiently, Ex-Earth's local representative, Hoak Hagbarth, took Giyt aside and made a suggestion. The current Earth mayor was retiring. They needed a new one. Why not the man who knew how to run the system? And when an election was held, to Giyt's astonishment, he won by a landslide.

He discovered that one reason no one had specially wanted to compete for the job was that its duties were mostly ceremonial, but it did have

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one obligation. The Earth mayor, along with his opposite numbers from the five alien species, was required to take a seat on the planet's Joint Governance Commission.

The aliens were a bit of a shock to Giyt and his wife. They came from five planets of four different stars, and not one of them looked at all human. There were the Delts, so-called partly because their planet's star was Delta Pavonis, partly because of their triangular heads with their independently wandering eyes; the Delts were the race charged with providing the community with electrical power from their fusion plant on a nearby island, and their company wasn't particularly pleasant because they smelled bad. There were the Petty-Primes, tiny hairless bipeds about the shape and size of marmosets; they were the easiest of the aliens to get along with, and Rina was enchanted with their friendly, kitten-sized young. The Kalkaboos were more or less primate in architecture but with glittery, solar-paneled skins, and the only thing Giyt and Rina found to object to in them at first was their every-morning religious ritual of setting off huge firecrackers at sunrise to blow away the previous day's sins. Finally there were the two races from planets of the star Alpha Centauri. The Slugs looked more or less like large, furry-skinned amoebae, extruding eyes and members as necessary; they liked a damp climate, so they occupied a village of their own down in some sludgy, river-bottom land, outside of the community where all the other races lived. The Centaurians looked, more than anything else, like curly-haired anteaters. What struck Giyt and Rina as most curious about them was that, although the female Centaurians were roughly the size of sheep, their males were not much bigger than mice and spent most of their time clambering around the fur of their mates.

It was those two, the Slugs and the Centaurians, who had first settled the planet Tupelo, after fighting a devastating interplanetary war against each other a little earlier. When they met on the new planet they had learned their lesson. They signed a treaty of perpetual peace on what they called the "Peace Planet," and as new races arrived they were required to sign it as well.

The meetings of the Joint Governance Commission were simplified in one way by means of little earplug translators, so that at least the various races didn't have to learn each other's forbidding languages. What made them complicated was that, in spite of the name of the planet, the meetings were seldom all that peaceful. The Delt High Champion (as the Delts called their leader) was the first to make trouble for Giyt, but most of the members were equally determined to insist on the rights of their species over all others. Only the Centaurian mayor-equivalent, Mrs. Brownbenttalon—her actual Centaurian title was "Divinely Elected Savior"—seemed truly pacific.

There were one or two other annoyances connected with the mayoralty. For one, Giyt felt obliged to set

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an example by taking part in community activities, like joining the volunteer fire department. Worse was the fact that, although he had very little real power—most decisions were made by Hagbarth, on behalf of Ex-Earth—a good many citizens didn't seem to understand that, and so he was constantly besieged with complaints and requests for favors.

A minor inconvenience was Tupelo's unexpected thirty-four-hour day, but even that had its compensations; Earth humans adapted to it by adding a four-hour siesta to their diurnal schedule, and Giyt and Rina found good uses for that. Rina, now a respectable matron, ventured to make contact with her estranged sister on Earth, who welcomed her back into the family. And Tupelo, after all, was full of interesting things for Giyt to do. Along with Amelia Patroosh, an expert from Earth, he visited the Delt powerplant on Energy Island and planned to take the suborbital rocket to the planet's factory complex on the polar continent.

But there were some puzzles.

For one, there was a nagging question: if the FTL portal-to-portal transport system was really the invention of the Earth scientist, Sommermen, how did it happen that all the aliens had been using the same system long before an Earth human ever got there? And—although the humans on Tupelo referred to themselves as the "Earth colony"—wasn't it a bit strange that every one of them came from one single nation, the U.S.A.?

Giyt's relationship with Hagbarth began to deteriorate when the Ex-Earth manager asked him to try to slip a measure through the Joint Governance Commission that would allow Hagbarth to import some handguns—"for protection against ferocious sea predators," Hagbarth said. When Giyt tried to oblige he was shouted down by all the other members, because that was one of the things the Peace Treaty specifically forbade. And then he got in trouble with the Kalkaboos. It wasn't Giyt's fault. As part of his duties as a volunteer fireman he was tending a booth at their fund-raising fair, the "Taste of Tupelo," when the Kalkaboo High Champion became upset at something Giyt had done and died of a stroke. The Kalkaboos blamed Giyt for their leader's death and demanded he pay penance by blowing up an immense firecracker of his own. Moreover, Kalkaboo customs required that the new High Champion vanquish his predecessor's killer in a purely symbolic fight. But Giyt misunderstood and fought back, and so he was in worse trouble with them than ever.

The Centaurian female, Mrs. Brownbenttalon, remained friendly to Giyt. She invited him to a party at her house, where she promised to help him with his Kalkaboo problem. It was important to clear that up, she said, because in a little while there was going to be a meeting of representatives from all six of the planets represented on Tupelo—not the Joint Governance Commission, but actual VIPs from the home planets—and there should be no local dissensions when that happened. She

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also told him that his suspicions were correct; Sommerman didn't invent the FTL portal, it was developed by the aliens and they made a gift of it to Earth.

Giyt wondered why Ex-Earth, and everyone connected with it, had lied. He wondered, too, about the financial structure of the colony on Tupelo, which seemed to be heavily subsidized by whatever shadowy figures were behind Ex-Earth for unclear reasons.

When he asked Hagbarth about these things, the Ex-Earth man evaded the questions but tried to pump Giyt about everything Mrs. Brownbenttalon had told him. The aliens, Hagbarth claimed, were keeping too many secrets from the Earth humans. He told Giyt it was his duty to his planet to wear a recording device next time he saw the Centaurian female, and to try to pump her about her planet's military capabilities. Giyt refused indignantly, and Hagbarth warned him he would pay for it. For one thing, he had somehow found out about Rina's past history on Earth as a prostitute, and tried to use it as blackmail.

This was a blow below the belt. Rina was pregnant with Giyt's child; what had begun as a sexual convenience, and continued because Ex-Earth wanted only married couples to colonize Tupelo, had turned into a real love. Nevertheless, Giyt refused to spy on a friend, and harassment began.

The first signs were staged complaints about Giyt's misconduct as mayor, then the rumor about Rina's past began to spread. And when they returned to their home after a visit to Mrs. Brownbenttalon they discovered their backyard pipes had been mysteriously dug up and their plumbing didn't work; the harassment had become physical.

Part III
XIX

Good morning, guys and guyinas, it's me again, your Voice of Tupelo, Silva Cristl, with a weather report that'll cheer you up. The bad news is that Hurricane Sam has intensified overnight; now it's Class Five, with winds over 300 kilometers an hour. The good news is that it's going to miss us. We'll get some rain out of it, sure, but we'll miss the big winds. Speaking of big winds, did you hear there's a movement to rename the hurricane? People don't want to call it Hurricane Sam any more. They want to call it Hurricane Evesham, because it's a lot of hot air that misses the mark.
—Lt. Silva Cristl's morning broadcast

Giyt didn't want to talk to Hoak Hagbarth. Given a choice, he would have cut the man out of his life entirely, but the mess in his backyard left him little choice. Something had to be done.

When he tried to call Hagbarth about getting it fixed the man didn't answer his personal communicator; when he called the Hagbarth house it was only Olse Hagbarth who was there. "You say they dug up your backyard? Really? Well, I did hear something or other about a complaint

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of stopped-up drains a while back, but I'm afraid I wasn't paying much attention."

When Giyt asked who had made the complaint she only shrugged. "I guess you'd have to ask Hoak about that. Well, no, he isn't here right now. He's in a major meeting—you know, getting ready for the six-planet congress—and I can't interrupt him. Anyway, the sewers are Slug business, you know. Why don't you file a requisition? Although they're so backed up with the congress coming, heaven knows when they'd be able to get around to it."

She was right about that. The Slugs were so busy getting ready for their VIPs to visit that there wasn't a single Slug in the waterworks office. In fact, there was only one person there, and that person—oh, when your luck was bad it was bad all the way—was a female Kalkaboo.

When she saw Giyt coming she raced him to the door, but he got inside the office before she could lock him out. Sulkily, she retired to her desk.

At first Giyt thought she wasn't going to talk to him at all, but evidently her sense of duty overcame her revulsion. "Have no authority accept requisition," she told the air, unwilling to look Giyt in the face. "Slugs all in Slugtown, performing extremely great group sing for safety of soon-arriving leaders. Go away."

"But it's an emergency," Giyt protested.

"Yes, of course emergency, what difference? This work you are complaining not done by Slugs anyway. No work order in file. No progress report. So not Slug, so Slugs probably not going fix anyway. You don't like? You ask head Slug about same at commission meeting of joint governance, see how much good that do you. Go away."

The visit to the waterworks office wasn't quite a total loss. At least he had found out that the ruin in his backyard wasn't part of some official maintenance program. Which left only one possibility: it was more of Hoak Hagbarth's teaching Giyt a lesson.

The ameliorating fact was that the lack of waste-water disposal wasn't a *desperate* emergency. The de Mirs had offered them the use of their own facilities at any hour of the day or night. Then, when Giyt got back from the waterworks office, he inexpertly managed to hook up a hose drain to the kitchen sink. It took an hour of swearing and getting wet, but when he was finished Rina could at least cook, the waste spilling out onto what passed for their lawn.

None of that helped to alleviate the smell from the backyard.

Smoldering, Giyt snapped on the human-language broadcast to take his mind off Hagbarth's malice. What was on was a delayed broadcast of an Earthly hockey game. He watched it unseeingly until Rina called to him. "Hon? You haven't forgotten you've got a Commission meeting coming up?"

He had. What's more, he had also completely forgotten about Mrs. Brownbenttalon's promise to mend matters with the Kalkaboos.

Mrs. Brownbenttalon hadn't,

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though. By the time Giyt got more or less cleaned up from his exploits with the kitchen drain there was the Centaurian, leaning out of a cart before his door and calling to him. "What you do," she instructed as soon as he was inside, "is totally prepared by me. You perform return bout with new High Champion, OK? Nothing serious, you understand. No maiming. But element of paramount importance you must remember is you positively must not this time win." She bobbed her long nose at him for emphasis. "No more discuss this, please. What is terrible smell?"

And when Giyt told her about his troubles with the Slug repair crews she sighed. "Slugs," she said mournfully. "Who can do anything with Slugs? Perhaps you do like Kalkaboo lady say and ask head Slug at commission meeting, maybe he in good mood. Usually not. Now we have conversation of trivial matters so you compose yourself. You like this fine weather we having now, temporarily?"

There were a dozen or more persons milling around outside the door of the Hexagon, humans and eeties mixed. Giyt eyed them warily, but there did not seem to be any Kalkaboos among them. As Giyt entered one of the men caught his arm. "Where the hell are we supposed to sit, Giyt?" he demanded.

Actually it was a fair question. Inside the building Delt and human crews were ripping out most of the seats usually supplied for the audience. New, and obviously a good deal more comfortable chair-equivalents were stacked along the wall, ready to be installed for the comfort of the delegations. Giyt gave the man a helpless shrug and entered cautiously.

All the other members were already in their places, even the Kalkaboo High Champion, who did not even look at Giyt. Mrs. Brownbenttalon piped to the room in general, "Sorrow for lateness. I and Earth human had business of non-public nature. Please begin."

And the Principal Slug—acting as chair for the day—slapped the desktop with one extruded member for order, commanded the work crews to stop their noisy activities, and began the meeting.

It was not a peaceful one. It seemed that every member of the Commission had a complaint to make or a demand to register. The Principal Slug was first, usurping the privilege of the chair to point out that there were not enough damp-conditioned carts available in working order for the use of their delegation from the Slug home planet. Then the Petty-Primes' Responsible One protested that the traffic involved in preparing for the meeting was so heavy that their small carts were at risk of being run over in the streets, and then the Delts weighed in by announcing that the other members of the Commission were taking up time on frivolous matters when they should have ratified the seat assignments on the suborbital polar rocket and, really, they should move along so the work crews could finish preparing the hall for the six-planet meeting. Even Mrs. Brownbenttalon indignantly proclaimed that all that

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work should have been completed long ago, because more staff members for the six-planet meeting would be arriving very soon, and the accommodations for the Centaurians were not ready.

It did not take Giyt long to figure out what was motivating them all. The audience was much larger than usual, uncomfortably perched on whatever surfaces were left for them. Most of them were eeties—Giyt even saw the female Kalkaboo from the waterworks office—and among them were a number he had never seen before.

Those newcomers, he realized, had to be advance staff members for the delegations from the home planets. What the mayors were doing was showing off for the high brass. Only the new Kalkaboo High Champion was silent. He did not speak, did not look at Giyt, hardly moved at all except for the flapping of his huge ears. The only time he paid any attention at all was when Giyt found an opening to bring up his own business with the Principal Slug. Then the Kalkaboo conspicuously turned his back, while the Slug in the chair slobbered reprovingly, "This purely unofficial personal matter, Mayor Giyt. Not to come before this body never. No other proper business? Good. Meeting I now adjourn."

Well, Giyt thought, he hadn't really expected any more. Meanwhile, what about this other matter? He started to ask Mrs. Brownbenttalon what had gone wrong with her arrangements with the Kalkaboos.

That was when he found out that nothing had gone wrong at all.

He had incautiously turned his back on the High Champion. Before Giyt knew what was happening, the Kalkaboo leaped off his platform and bore him to the ground. "Die in wretched agony, vicious murdering person!" he shrieked, pounding Giyt's head against the floor. But not really very hard, and not for more than a moment. Then the Kalkaboo rose and said politely, "Thank you. Vengeance is now complete. Expect you recover from this beating soon."

When vengeance was complete, it seemed, it was complete, and it produced some unexpected dividends. The High Champion of the Kalkaboos did not become friendly, exactly—friendliness did not seem to be among the behaviors in the Kalkaboo repertory—but he did something better. He beckoned to the female Kalkaboo from the Slug office and whispered into her great ear. She in turn spoke to the Principal Slug, who listened for a moment, then called to Giyt. "Am informed repair requisition of you on file, so work will be done. Is quite irregular. Slugs, however, always cooperate reliably, this our nature."

And then the next morning, as he was breakfasting with Rina at daybreak, they heard the pop of an explosion outside their own door. When they peered out they found it was pouring, but they caught a glimpse of a Kalkaboo running away in the rain. "I guess they didn't trust you to set off your own firecracker, Shammy," Rina said. "Anyway, it's all straightened out now, right?"

"Looks that way," he said, and returned to his pancakes, more cheerful

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than he had been in days. At least the problems with the extraterrestrials on Tupelo seemed to be healing themselves.

The humans, however, were a different matter. The stresses there were not healing themselves. They were getting worse.

XX

The last species to reach Tupelo before the arrival of the Huntsville probe were the Petty-Primates. Once again, the identity of the solar system they come from has never been established. although it seems clear that, in the conditions that affect life, their planet was quite like Tupelo, and thus, no doubt, a good deal like Earth itself.

Physically, the Petty-Primes are tiny. More than any other terrestrial creature they resemble tailless, hairless monkeys. Yet, with a brain less than a tenth the size of a human's, they have demonstrated enough intelligence to develop a highly sophisticated technological culture. That is surprising in itself. But the Petty-Primes have another quality that is still more unlikely.

That is their life span. Earthly ethologists have drawn a sort of curve, plotting mass against longevity for mammalian species, and it demonstrates that the smaller the creature, in general the shorter its life expectancy. Not the Petty-Primes. They are completely off the curve. Their childhood extends for nearly thirty years so that by the time a Petty-Prime is sexually mature it has gone through decades of learning and experience. The length of their lives as adults is equally astonishing. When the first humans reached Tupelo some of the original Petty-Prime colonists were still alive and well, though since then most have either died or returned to their home planet.

—Britannica on-line, "Tupelo"

The more Evesham Giyt thought about it, the more he was convinced that the world would be a better place if Hoak Hagbarth weren't in it, either back on Earth or, preferably, dead.

That was a conclusion that startled him. Giyt had never before in his life wished for any other person's death. It wasn't that he planned to do anything about it. He had no intention of a shoot-out with Hagbarth, even if either of them had weapons to shoot each other out with. But to punch the man stupid, yes, that was a tempting option. Bash him bloody and then kick his ugly face in—yes, definitely that scenario had real attractions for Giyt. . . . Or would have had, if Rina hadn't begged him to let the matter pass; "All he did was tell the truth, Shammy," she said, dry-eyed and somber. "The whole thing is my fault."

"*Nothing* about this is your fault!"

She gave him the pursed-lips look that meant, *You're entirely wrong and I'm certainly right, but I don't choose to debate it any further.* All she said was, "Please, Shammy. I'm asking you to let it go. For me."

Well, he couldn't let it go. But he couldn't go against the wishes of the mother of his unborn child, either. And while he was considering just

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what he could do, Rina cleared her throat. "You know, Shammy," she said, "if we had to go back—well, what I mean is, if we wanted to go back—it wouldn't be all that bad, would it?"

It took a moment for Giyt to understand what she was saying. Then he was firm. "Not a chance. We're not going to bring up our son in—"

"Or daughter," she said. "I haven't checked."

"Whichever. Anyway, we're not going to raise our family in some damn slide-room in Buena Vista."

She looked at him consideringly. "It wouldn't have to be in Buena Vista, Shammy. I've been thinking. My sister and her husband have a three-roomer. I'm sure they'd be glad to have us, just till we got settled—"

"That," he said, "is not going to happen. I give you my word, Rina. We're going to bring up our kid right here on Tupelo."

So Giyt had made his wife a promise.

Evesham Giyt didn't have a lot of experience in keeping promises, hadn't been in the habit of giving any to anyone. This one, though, he was determined to keep. He was not going to allow Hoak Hagbarth to kick them off the planet of Tupelo.

But then, when he had begun to search for these "regulations" that Hoak Hagbarth could invoke when he chose, it began to look as though that might present some problems. There was in fact an Ex-Earth statute that said any colonist could be deported for aggravated antisocial behavior. The language was opaquely legal, but when Giyt read it over he saw that it could have been that sort of charge that had terminated Shura Kenk's residence. Could have, at least if she was guilty after all, of whatever the de Mirs chose to believe. What was less clear was whether it could be used against Rina. Could it, for instance, be made retroactive to cover acts committed light-years away and years in the past?

On the third or fourth rereading he still couldn't tell.

"See," Rina said when he complained to her, "you're really smart about most things, hon, but that's lawyer talk. People like us aren't supposed to understand it. You need somebody to tell you what it means. You need a lawyer."

"Well, do you suppose there are any lawyers here on Tupelo?" he asked, studying her. She seemed subdued, naturally enough, but as far as Giyt could tell she hadn't been crying. But then Rina wasn't ever a cryer.

"The way to find—" she began, and then paused as a message flashed on his screen. They both looked at it; it told Giyt that the first official group of delegates for the six-planet conference was about to arrive, and his presence was required to greet them.

Giyt groaned. Rina shook her head. "You'd better go," she said. "What I was about to say was that the way to find out if anybody here is a lawyer is to check the personnel files. You go change your clothes. I'll do it for you."

It didn't take her long. While he was brushing his hair she came in and leaned on the doorway, watching

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him. "There isn't anybody who calls himself a lawyer," she reported, "but I did a deeper search and I found two people who had a little legal experience, anyway. One worked as a paralegal, and the other dropped out of law school in her first year."

"Good work," he said, to cheer her up.

"Well, maybe so," she conceded, "but I don't think it helps us much. The paralegal's Olse Hagbarth. And the other one is Silva Cristl."

When Giyt arrived at the square in front of the portal the rain had nearly stopped, which was a good thing, but there was something less good going on. He had expected to find at least a couple dozen people there, waiting to greet the incoming VIPs. He didn't. There was no one there at all except for a pair of Delt workmen, tinkering with a cart at the edge of the square in spite of the continuing drizzle. When he asked them what was going on one of the Delts turned a single eye on him, the other still gazing at the exposed mechanisms of the cart. "You don't hear?" the Delt said. "New word recently coming. Slug bosses being delayed, don't say how long. Maybe twenty minutes, maybe who knows?"

"Never say how long," the other one put in. "Slugs, you know? But maybe give us time to get this busted old junk pile juicy enough for delicate Slug persons before getting here, that assuming you let us go on with repairing task."

The delay was news to Giyt. He wondered whether the fact that he hadn't received the amended message was more of Hagbarth's petty harassment, or simple inefficiency. It didn't matter. Either way he had time to kill.

He considered going back home to wait. It didn't seem like a good idea. He might not be there long enough for any real purpose. He also might not get the word again in time to get back for the actual arrival, and why give Silva Cristl something new to gossip about on her broadcasts?

He moved away restlessly. He had a lot on his mind, but it didn't seem to want to concentrate on any one subject. As he wandered he was thinking about the turgid wording of the Ex-Earth regulations, and wondering whether the Slug workers had started to fix his drains yet, and noticing the fact that he was getting wet. Was the rain going to get harder again? Giyt had had little experience of hurricanes. He had checked out the weather reports and understood that the hurricane itself had missed their islands by a couple hundred kilometers; all they were getting was the arc of storms that spiraled around its trailing edge. He saw a few people moving around in the street, mostly eeties; they seemed to assume the worst of the rain was over, at least. . . .

Then he saw a pair of humans, and one of them was Hoak Hagbarth.

They seemed to be discussing something Hagbarth was displaying to the other man on his portable. When they looked up Giyt looked away; he didn't want to talk to Hagbarth. Evidently the feeling was mutual. Hagbarth gave him only a glance, then turned the other man with a hand on his shoulder and led him toward the

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portal. Giyt stared after them, trying to identify the other man—was it one of the people from the hypermarket? Probably, he told himself, that was one more sign of his failings as mayor of the Earth community; a good politician would know all his constituents by now. And Giyt admitted to himself that, whatever his other virtues, he wasn't a very good politician.

A whirring behind him made him turn to see a doll-sized Petty-Prime cart drawing up. The Responsible One leaned out. "Apologies for not offering ride to portal," he squeaked, "but you observe inadequate space in passenger side this my vehicle." He seemed to be making a pleasantry, so Giyt tried one in response.

"It's my fault for having too much growth hormone in my system," he said.

The Petty-Prime gazed at him blankly for a moment, then exhaled in a soft, uncomprehending sigh. "Anyway," he said, "express regret for potential for no longer sharing Joint Governance Commission duties, perhaps." He waved a small paw and accelerated his cart away.

Whatever he meant by that. Giyt really *had* to get at those translation programs one day soon, he told himself, and then remembered that maybe he wouldn't be present to have to worry about such things very much longer. Meanwhile, he had VIPs to greet.

When he got back to the square the keepers of the security switches were lounging by their posts, Hagbarth included, and a large group of Slugs were hooting one of their mournful hymns nearby. Other mayors were arriving, too. Mrs. Brownbenttalon poked her snout out of her cart and beckoned to him. "My husband here say to tell you congratulations on excellent fall you took for new Kalkaboo stinky High Champion," she said. "I share sentiment. Extremely well done, I say!"

"Thanks," he said, nodding at the tiny male in his wife's neck fur. "I hope I'm not late."

"Be commoded, Large Male Giyt. Is last-minute decision of Slugs to arrive early, laster-minute to be somewhat later, typical Slug thing." She paused to listen as her husband chittered in her ear. "Oh, yes," she said. "Have sorrow that—no, waiting a bit now. Hear warning dingle."

The chime had sounded to announce the imminent arrival of the leaders. As Mrs. Brownbenttalon flopped out of her cart the waiting Slug delegation redoubled their hooting, the people at the security switches came to attention, and the golden glow began to surround the portal as the field built up.

Then it was all very quick. The chamber door opened. There was the pop of expelled air from inside, the glow cleared, and two large Slugs appeared, eye stalks waving. They were immediately surrounded by Tupelo's own Slug delegation, escorted to the waiting damp-controlled carts and borne away.

Giyt blinked after them. "That's it?" he asked.

"That is the all of the it," Mrs. Brownbenttalon confirmed. already getting back into the cart that had

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brought her. "No orations. No shaking of hands, no sniffing of noses, nothing like that. Only all us dignitaries required properly physically present here at time of Peace Treaty delegation arriving or will take offense. Is a Slug thing," she added, looking around and lowering her voice. "Delts are even worse and, hey, you know all about Kalkaboos from own self's experience already, right? Esteemed Giyt wife possess wisdom creating associations only with Petty-Primes and Centaurians such as self. Presume former presently condoling."

"Condoling?"

He heard a tiny chittering as Mr. Brownbenttalon poked his nose out of his wife's neck fur and spoke confidentially into her ear. "Oh, is understood," she said to Giyt. "You don't know yet. Well, you hearing soon enough, Centaurians don't like telling bad news. We hope for seeing you in more happy time. Good-bye."

On the way home Giyt reflected on yet another cryptic utterance. He couldn't tell how much of the mystery was due to deficiencies in the translation programs, and how much to simple eetie weirdness; but as the cart approached his house he got a hint of what Mrs. Brownbenttalon had been talking about. There were Petty-Prime kits playing happily in the mud of the de Mir yard with the younger de Mir children, and on the de Mir porch were their mother, with both of the de Mirs and his own wife, talking earnestly to each other while the children played. As Rina caught sight of Giyt she excused herself and came toward him.

He was looking over her shoulder at the Petty-Prime female. "Isn't that the wife of your farming friend?"

"Ex-wife, actually; they change partners a lot, I understand. But they're friendly, and he told her something she came hurrying over to tell me. It's Hoak Hagbarth, Shammy. He's circulating a recall petition for you. He doesn't want you to be mayor any more."

XXI

It's official, all you misters and mizzes, they're getting ready to jump! Our official delegation to the Six Power meeting is getting final instructions from their governments, and they'll be arriving here on Tupelo in three days. Let's all be there to give them a good old Tupelo welcome! Because, remember, these aren't Ex-Earth people, these are the official representatives of the old United Nations, and that means they're speaking for the head honchos of the whole damn planet! So we want to look our best for them. Too bad there's one little piece of housekeeping that we probably can't have finished cleaning up by then—you all know what I mean! But there'll be plenty of time to take care of that later on.

—Lt. Silva Cristl's broadcast

If there was one experience that Evesham Giyt definitely did not want to have as mayor, it was being fired. If his term of office had come to its scheduled end he could walk away happily. He might even be willing to peacefully resign; in fact, that thought

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had crossed his mind more than once. But to be kicked out? No, that was something else. It was unacceptable.

It didn't take Giyt long to find out why they hadn't seen the recall petition on the net. Someone had, not very expertly, cut the Giyts and the de Mirs out of the basic loop, so that all that came to their personal screens was a censored version of what went to the whole community. Once Giyt had an idea of what to look for he located it in less than half an hour, and created a detour around the block.

Then he studied the petition with growing distaste. It wasn't very specific. There wasn't anything that actually said that Rina had once been a prostitute, or that accused Giyt himself of any serious misdeeds. But in and among all the whereases—presumably Olse Hagbarth's work, or Lt. Cristl's—there were a lot of words and phrases like "malfeasance" and "prejudicial conduct," and what they all added up to was that the people who signed the petition were asking for a special election to be held to kick Evesham Giyt out of his job as mayor.

Rina came in, and peered over his shoulder. "Lunch is ready," she announced, counting the names. "Seventy-six signatures," she said thoughtfully. "They need twenty-four more to make it count."

He turned to gaze at her. "How do you know that?"

"I looked it up, of course. It's what the regulations say, a recall petition must be signed by at least ten percent of the citizens, and that's one hundred. You know what I think, Shammy? I think they're having trouble getting the hundred. There are a lot of people who like you."

But there were a lot who didn't, too. While he was eating his lunch Giyt studied the signatures on the hard copy, trying to fit a face to each name. More than half the members of the fire company had signed. So had, he estimated, a majority of the various people who had asked him for favors at one time or another and been turned down. So had the former mayor and her husband, and all those were easy enough, if not pleasant, to understand. But there were at least a dozen signatures that Giyt hardly recognized. Certainly he could not remember ever having done anything to offend them.

When he said as much to Rina, sitting pensively across from him and nibbling a stalk of celery while he ate, she shrugged. "Hagbarth's had plenty of time to hand out favors. I guess they owe him, don't you think? That's how politics works."

"I suppose." Then he looked at her more closely. "You're not eating," he accused. She shrugged again, and he remembered some of the things he'd looked up about pregnancy. "Hey! What is it, is it this morning sickness business?"

"It turns out it isn't just in the morning," she admitted ruefully. "Now, Shammy, don't get all worried about it. It's just something that pregnant women do. I'm going to go to the clinic this afternoon for a checkup anyway, and they'll give me something for it."

"I'm going with you," he announced. "I— Wait a minute." There

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was an action message coming in on his screen, it said that the Delt delegation would be arriving in ninety Tupelovian minutes. "Damn," he said. "Well, I'm going to go with you anyway."

"Oh, hon. That's sweet of you, but what's the point? I can handle it by myself; you stay home and work until it's time to meet the Delts."

But Giyt didn't stay home, he went right along with her, as much to be ready to glare down any citizen who chose to give his wife any dirty looks as because he thought she needed company.

There wasn't any of that. Business was slack at the little hospital building, and the couple of people sitting in the waiting room seemed more concerned with their own problems than with whatever was happening with the Giyts. The doctor on duty took Rina into the examination room without comment, except to firmly veto Giyt's notion of coming with them, leaving Giyt with nothing to do but wait.

The proper place for that was the waiting room, but Giyt was too restless for that. He roamed around the little building, pausing in front of the window that looked on the cribs for newborns. There was only one baby there, with a medic who looked faintly familiar bending over her. Giyt wondered what it would be like to see his own child in that place, perhaps exchanging with other new fathers the ritual cigars that nobody was ever going to smoke—if anybody was going to be friendly enough with Giyt for that sort of sociability. If, for that matter, they were still going to be on Tupelo when the baby got around to being born.

The medic had finished what he was doing with his charge, saw Giyt outside, and came out to speak to him. "Remember me?" he asked. "I was the one who helped you with the kid that was choking? Anyway, I just wanted to tell you that I'm on your side. So's Cheryl here," he added, nodding to the woman who had come out of the pharmacy across the hall.

"So are most of us," she said, shaking Giyt's hand. "I don't go much for politicians, but I can stand you a lot better than that damn Vardesehn woman. She was always coming around and telling us what to do—at least you don't interfere."

So Giyt was in a much better mood when Rina came out of the examining room. "She gave me a patch," she says, showing it. "She says that'll control the nausea—and, listen, hon, you don't have to come home with me. Go welcome the damn Delts. You're a sweet man, but you worry too much."

But actually, he told himself on the way over to the portal, he couldn't help worrying about her. Maybe "worrying" wasn't exactly the right word. He was sensible enough to know that morning sickness wasn't a life-threatening kind of thing. What was on his mind was that he wanted to protect her. Evesham Giyt, who had never concerned himself with covering any ass but his own, had now assumed total responsibility for the well-being of the woman he had married. It wasn't a rational thing; it was the old story of the caveman

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guarding his mate.

And when he got to the square and saw Hagbarth preparing to take his place at the switches he gave the man a belligerent look, but succeeded in not going over to him and punching him in the nose. Hagbarth looked startled and turned hastily away. Which gave Giyt some minor satisfaction.

All the other mayors were there, with a large company of Delts waiting to greet their dignitaries. Giyt nodded to Mrs. Brownbenttalon, returned the gesture when the Petty-Prime Responsible One waved a paw at him, even got a greeting from the new Kalkaboo High Champion. One of the Delts broke ranks to come over to him; Giyt recognized him as the pilot from their trip to Energy Island. "Hey, you Earth Person Giyt," he said affably, both eyes on Giyt. "Greetings. Regrettings, too, because hear stinky Hagbarth person trying screw you. Pity. All us Delts think you not quite so bad. Comparing to other Earth persons, I mean. Sorry we can't vote, this matter none of our business, you know."

"Well, thanks," Giyt said, somewhat touched.

"Anyway," the Delt went on, one eye wandering toward the portal, where the golden glow was just beginning to develop, "what I wanted asking you, what do you think? How long you guess it take them for bouncing you out? Reason want to know, can then get bets down in the pool."

By the time Giyt got home again he felt reasonably sure that, if the recall vote included all the eeties on Tupelo, he would probably win in a landslide. It didn't, of course. But, all the same, it was a cheering thought, at a time when such thoughts were scarce.

Rina greeted him at the door, looking flushed and pleased with herself. "I've got something to show you, Shammy. Come in here a minute."

What she had to show him was her screen, which was displaying a freeze frame of eight or nine human beings, all looking either solemn or angry or just dejected. "It's that Shura Kenk's deportation hearing, hon. It took a little hunting, but I found it. Only I don't think it's much use for what we want, because there aren't any lawyers there, either."

She touched a key and the picture began to move, Giyt gazing wonderingly at it. It wasn't much of a trial, if that was what it was supposed to be. Not only weren't there any lawyers, there didn't seem to be any witnesses, either. Former Mayor Mariam Vardersehn was sitting in what appeared to be the chair, while Hoak Hagbarth was reading a list of accusations concerning Shura Kenk. Shura Kenk sat in a straight-back chair, listening but hardly speaking; she was the one who looked dejected, and had reason enough.

There did not seem to be a lot of justice being dispensed at this hearing. Even the complainant, the twelve-year-old Grayhorn boy, wasn't present. When Hoak Hagbarth had finished, the half-dozen others in the room—Silva Cristl and three or four others Giyt recognized to be from the firehouse prominent among them—whispered among themselves for a moment or two. Then Cristl nodded to the mayor. "Looks like she's proba-

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bly guilty, Mariam," she said, "and anyway what can we do? The eeties wouldn't have any respect for us if we let somebody like that stay here. So she has to go."

That was it. All that was left was for Mayor Vardersehn to pronounce the sentence. "Since a jury of your peers has found you an undesirable presence on this planet," she lectured, "you are hereby given forty-eight hours to collect—what?" As Hagbarth was whispering to her. "Oh, sorry, I was thinking of something else. You're given sixty-seven Earth hours, two Tupelo days that is, to collect your belongings and report to the portal for return to Earth. The session is concluded."

"What do you think, Shammy?" Rina asked anxiously as the screen went black.

He said, "I think it's a classical frame-up."

"Well, yes, but did you notice something else? Do you remember what Lupe said, that Kenk claimed the real reason they were out to get her was something about the Pole?"

Puzzled, Giyt looked at her. "But she didn't say anything about the Pole."

"Right, hon. Like that old Sherlock Holmes story, you know? Dr. Watson asks him what was interesting about the dog barking? And Holmes says, why, just the fact that it didn't bark at all. Do you see what I mean? Shura Kenk didn't mention the Pole at her hearing."

XXII

The physical plant on Tupelo's polar continent comprises fourteen main manufacturing domes scattered over nearly four hundred square kilometers. These are in general linked by covered passages, supplemented by robot ground-effect vehicles to transport materials back and forth. In addition to the main complex there are eleven additional sourcing sites. Those are mineral mines, where robot moles sniff through reefs of ore and extract it for processing, and refineries. There the ore is cooked into pure metals, then batch-processed into whatever alloys are required for scheduled production runs in the factories. In addition there are six relatively small oil and natural-gas wells, providing fuel for the polar continent's dedicated powerplant as well as feedstock for its chemical factories.

The autofactories themselves receive these raw materials and fabricate them into whatever is required for the use of the inhabitants of Tupelo, or for export to their home planets.

—Britannica on-line, "Tupelo"

Shura Kenk not only hadn't said anything about the Pole at her hearing, she hadn't said anything at all. Nevertheless Giyt took his wife's words seriously. He had decided long since that, although Rina's reasoning was sometimes a little hard to follow, she was usually right.

So he sat himself down to recheck everything there was in the databank about the polar factories. A lot of the information was in what Hoak Hagbarth had presumably thought to be

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secured files. That wasn't much of a problem to Giyt. What was a problem was what he had discovered on his first look at Ex-Earth's business correspondence. A lot of the most potentially interesting material used code words for whatever it was talking about.

What was even more of a problem was that he didn't know what he was looking for.

At the end of two hours' digging he had found out more than he ever wanted to know about the products of the Earth factory at the Pole. In recent months the machines had turned out a bewildering variety of cookwares and clocks, underwear and utensils, dolls and toys in a dozen varieties, construction materials, personal hygiene products, bed linen, cutlery—all routine stuff, as far as Giyt could see. It all appeared to be properly accounted for, too. Bills of lading showed that the goods had gone into the robot subs that carried them to the island, and then either to the hypermarket or, as export goods, to the portal for shipment to Earth. Almost all the runs were small. That wasn't surprising; that was the special virtue of an autofactory. At need you could produce, say, six gross of carpenters' nails if you wanted them, and you could make them in a dozen different sizes. For that matter, you could make a single nail if you happened to want just one. You could make just about anything at all, as long as the manufacturing specifications were in the factory's memory and the raw materials were at hand. And the specifications were. There was file after file of manufacturing protocols for endless lists of components for endless items—most of them incomprehensible to Giyt. What, for instance, was the purpose of one file, apparently unerased because forgotten, which contained a complete set of stats for eetie body odors?

That one Giyt could not figure out. Were the colonists perhaps planning to create a line of dolls to export to the eetie planets?—because they were programmed to odor-respond only to eeties? It seemed like a dumb idea to Giyt. If the Centaurians or the Kalkaboos wanted anything like that they were perfectly capable of manufacturing the things themselves. Or—he thought ruefully—maybe it wasn't all that dumb. If someone as resourceful as himself couldn't figure out what they were doing with the data maybe its inclusion was quite smart.

When he checked on what the factory was currently making he got another surprise. All the screen had to say on the subject was a legend: *Currently under manual control.*

That didn't make any sense at all. Autofactories weren't ever run by manual control, except, maybe, in the brief periods when someone like Giyt's father was teaching the machines how to assemble a particular device. Assuming the polar factory was that quaintly old-fashioned, which Giyt couldn't really believe it was.

Then he discovered another curious thing. Checking the production runs of the last month's output he noticed that the factories seemed to have been idle for quite a lot of the time.

That was, at the least, an inefficient use of facilities. If nothing else, the

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factory might as well have been churning out more clocks and toy airplanes to go back to Earth. But there it was. Production was apparently halted for days on end, more than once, though raw materials seemed to have continued to flow in.

He leaned back, taking a sip from a cup of cold coffee, regarding the screen. Maybe Shura Kenk had been on to something. Was something odd really happening at the Pole? And, whatever it was, who was doing it? Hagbarth was the leading candidate, of course; but what was the man up to?

Just for curiosity's sake—and because he was stabbing into the files at random, anyway—he spent a quarter of an hour trying to find out what some of the eeties might be doing with their own factories at that moment. He chose the Petty-Primes, because he had already broken their basic protocols, but all he found out was that they were making 512 of one listed item and 4096 of another, but what those items actually were he had no idea.

Still . . .

The numbers made him think of those other cryptic inventory numbers he had observed long ago. He searched for that file again, and when he found it he glumly regarded the lists of TARBABIES and GRABBAGS and RUTABAGAS and COPTS. They meant no more to him than they had the first time he saw them. But numbers were numbers, so Giyt did what he had done successfully so many times before. He set up a program to look for coincidences anywhere in the files of Ex-Earth, in the stats from the factories themselves, in the personnel files of Hagbarth and his wife—anagrams, birthdays, anniversaries—anything that might match the numbers.

When fatigue finally drove him to lie down for a little rest he let the program run. He had trouble getting to sleep. He didn't seem to be getting anywhere. But he had no place else to go.

When Rina woke him to tell him that his presence was requested to greet the incoming Kalkaboo delegation, she had two other items of news. The Slugs had finished repairing their drains, and now they could use their own toilet again. And Hagbarth's petition seemed to have plateaued out: "He's stuck at eighty-nine signatures," she said with satisfaction. "He needs eleven more, and I don't think he's getting them."

It didn't take long to see that the Kalkaboos were officially greeted—only a small ceremony, with minimal fireworks—and then, almost immediately, the next delegation was due.

They were the Petty-Primes. There were a lot of them—eighty or more, Giyt guessed, so that it took three portals-full to get them all to Tupelo. The Responsible One and his entire family were joyously bustling around, affectionately greeting every one of the scores of arrivals by name. It took forever. Mrs. Brownbenttalon seemed amused. The Delt General Manager and the Kalkaboo High Champion were stolidly patient and the Principal Slug, of course, was a Slug. It was only Giyt who fretted over the length of the proceedings; and then, when all three

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batches of VIPs had arrived, the Responsible One had something else to keep everyone there. There was a meter-high platform, more like a picnic bench than a stage, and the Responsible One lined up fourteen of the most important members of the delegation on it as a sort of receiving line. One by one, every non-Petty-Prime in the crowd was walked past. There wasn't any hand-shaking, exactly—too much danger of crippling a tiny Petty-Prime paw in a huge human fist or sharp Centaurian claw. So they merely touched digits and exchanged greetings.

It was the kind of meaningless event that Giyt would have done his best to avoid. He didn't want to hurt the Responsible One's feelings, though. The little creature had been kind. Besides, exchanging a few meaningless courtesies took very little conscious thought. Giyt went right on thinking about the polar factories as he patiently plodded along the line. For a moment he considered taking the Responsible One aside—or Mrs. Brownbenttalon or one of the other mayors—and asking if they had heard anything, well, *peculiar* about human goings-on in the polar complex. But it might be an embarrassing question for them. Anyway, what could they know?

As he left the line he saw Hoak Hagbarth and his wife just entering it, between a Centaurian female and a pair of Delts.

That gave Giyt a new thought. The trouble with the Pole, with all its mines and autofactories, was that it was nearly nine thousand kilometers away. He thought of Hagbarth's amiable offer, made back in those long-ago days when Hagbarth was still being amiable, to fly him up there on the suborbital rocket for a sightseeing trip. He wondered if he could find anything useful if he went there in person. Then he wondered if that offer was still open. Probably not. Besides, it would mean leaving Rina alone to face whatever nastinesses the Hagbarths might think up next.

He nodded his farewells to the eeties he knew and went home, his mind still turning over all the questions and worries that did not seem to find any solution. And when he sat down at his screen he found that at last he had been given a break.

Something had turned up in the program he had left to run. When all the numbers had been crunched, it turned out that the number of COPTs was precisely the difference between the number of chiplets reported on hand at the beginning of the month and the number reported as used in the manufacture of all the items the factory produced that month.

There was no doubt about it. Far more chiplets were being imported than ever went back into the dolls and gadgets the Earth human polar factory ever shipped out, and the numbers were not small.

Someone was stealing. And that someone could only be Hoak Hagbarth.

Giyt sat back, considering what to do next.

If this had been one of the great corporations he had occasionally worked for on Earth, his job would have ended right at that point. All that

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would have been left for him to do was to turn the information over to the head of security. Chiplets were smaller than sequins, but they cost money. Big money; some formerly trusted employee would soon be facing a spell in jail.

The trouble was that it didn't add up.

True, the fiscal systems for the human colony had been pretty badly designed and worse run. That was why Giyt had had to fix them, and ultimately why he became mayor. But what was Hagbarth going to do with a couple thousand stolen chiplets?

He could re-export them to Earth and sell them there, sure. They would be worth quite a lot. But that meant having confederates in the Ex-Earth organization on Earth. And anyway the sloppiness in the fiscal systems that let him cover up that theft could just as easily have been subverted in some simpler way—say, to divert credit balances to a dummy account like Giyt's own.

Rina came in, yawning, to bid him good night, and then got a good look at him. She came alert. "Shammy, what is it?"

"Minute," he said, double-checking, just to make sure. The machines were surpassingly good at arithmetic, but you never knew. . . .

He did know. There were no mistakes. "Look at this," he commanded, and when Rina had taken in what was being displayed on the screen she looked less triumphant than puzzled.

"Why, Shammy? Why would he go to all that trouble when he could just steal the money the same way—well, you know what I mean."

"I do. I thought the same thing myself, but there it is. What I don't know is what to do about it."

"Why," she said, stooping to kiss him good night, "sure you do, hon. You're the mayor. Mayors are supposed to uphold the law. So do it."

Do it. She was right. Apart from any personal satisfaction he might get out of it, Hoak Hagbarth was a criminal and he ought to be brought to justice.

But brought to justice how?

That was a harder question. He could report the matter to Ex-Earth. But who would he be reporting to? Almost certainly Hagbarth had confederates back there on Earth, probably in Ex-Earth itself, and wasn't it likely they would be the ones to receive the report? Perhaps he could spread the word to the American law-enforcement agencies. But what would they care about something that happened on Tupelo?

So he had some very valuable information, but who could he tell it to?

Just as he was puzzling over this another message appeared on his screen. The Earth delegates were arriving. There would be six of them, the notice informed him, and when he checked the names he saw that only one of them was an American. That, of course, was because this time it was the old United Nations, not Ex-Earth, who had supplied these ambassadors.

But that one American was Dr. Emilia Patroosh, the woman who had gone with him to Energy Island; and so Giyt had his answer to at least one question.

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* * *

He got to the portal just as its golden glow collapsed. Besides the obligatory eetie mayors, twenty or thirty Earth humans were waiting to greet them. Most of them, he saw with some surprise, seemed to come from the fire company, both Hagbarths among them. Olse glanced at Giyt as he arrived and gave him a small, reproving shake of the head.

But she didn't speak, because both the Hagbarths had more important things on their minds. As soon as the transmission was complete Hagbarth leaped down from his post in the control loop and advanced on the six Earth delegates, all smiles, hand outstretched to reach any other hand it could reach. He wasn't the only one. A dozen of the other Earth humans, Olse included, were moving purposefully to greet the newcomers.

The plenipotentiaries were an oddly assorted lot for Tupelo. One was a tall, mournful-looking woman with purple-black skin and a bright bandanna over her head—a Maasai from Kenya, according to what the roster had said. There was an elderly Swiss man and an even older Korean one; one Egyptian, one New Zealander . . . and Dr. Patroosh.

She was the one who counted. Giyt tried to push his way toward her. . . .

And got nowhere. A large hand gripped his arm and a voice from behind said, "Want to do something useful for a change, Giyt? Give us a hand with the goddamn baggage."

It was Wili Tschopp, looking unfriendly. Giyt tried to pull his arm free, without success, as Tschopp was tugging him toward the stack of bags and cases. "Let go," Giyt said. "I want to talk to Dr. Patroosh."

"But she don't want to talk to you, Giyt," Tschopp said reasonably. "Look, she's gone already."

And she just about was; Hagbarth was deferentially helping her into one of the waiting carts and getting in beside her. Most of the other ambassadors were boarding carts as well, except for the tall Maasai woman, searching through the baggage for something of her own, pausing to look at them curiously. "What's the trouble?" she asked, her voice surprisingly deep.

"Nothing," Tschopp said, while Giyt simultaneously said:

"I'm the mayor here. I've got something important to say to Dr. Patroosh."

"Oh," said the woman, peering down at his face. "Yes, I've heard of you."

"Then help me—"

But she was shaking her head. "I do not think I can," she said. "We're here to represent our whole planet, Mr. Giyt; we can't get involved in local disputes like this recall question. Dr. Patroosh shouldn't talk to you at all, and neither should I."

XXIII

This is your overnight weather report. Farm areas west of the central massif will experience occasional showers, growing heavier by daybreak. East of the massif, upper levels, possible showers and windy; at town level, partly cloudy with a high of 24°; near shore, warmer but dry.

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The polar station has a 90% probability of a major snow event, as the hurricane which narrowly missed the islands has moved north by northeast and appears to be joining a circumpolar low, possibly creating near-blizzard conditions.

—Tupelo weather service

Evesham Giyt wasn't in the habit of taking no for an answer, especially when the no came from someone other than the person he wanted to ask. Although it was the middle of the night, as soon as he got home he tried calling Dr. Patroosh. She didn't answer, neither on her personal access code nor the one for the house she had been assigned. When the fourth or fifth call wasn't answered he put his clothes back on, called for a cart, and had himself driven over to the house. It was as dark as all the others around it, both human and eetie, and no one responded to his knock.

Frowning, Giyt went home again. There had to be a way to reach the Earth delegate, but what was it? With Rina softly snuffling—you couldn't call it snoring—in the next room, he sat down at the screen again.

There wasn't much for him there, either. When Giyt tried to access the polar manufacturing program again, he once again got the "manual control" legend.

That was highly improbable. It was also what he had more or less expected. Something was definitely fishy at the polar factories, and try as he would he could not find a way into the mystery.

The answers were either on Earth or at the Pole itself. Going to Earth wasn't an option, if only because his departure would be a victory for Hoak Hagbarth. Should he go to the Pole, then? When he checked the schedules he found the suborbital rocket was on the island, due to return to the Pole the next day. He could bully his way onto it as mayor, he thought.

But he wanted to know what was happening on Earth, too.

It didn't take Evesham Giyt long to find an answer to that. He set about creating a super-scout, the most complicated of his career, to sniff through the entire net until it found just what Hagbarth and his gang were up to.

It took time. It would take more time than that to produce any data that would be any use to him; he encoded it to go to Earth in the next transmission, but then, even after it had found out what he wanted to know—if it did—it would have to wait for another transmission to report back to him.

At least it was a tangible step. When weariness finally drove Giyt to bed he felt he had accomplished something.

Dawn was lightening in the east when the din of Kalkaboo fireworks woke him. They seemed louder than usual; some of them must be expiating particularly nasty sins, Giyt thought, maybe to impress the delegates from their home planet. By the time he was dressing after his shower the noise had stopped, the sun was well and truly up, and Rina stuck her head in their bedroom to remind him that there was a note on his screen.

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The Centaurians were arriving.

Giyt had more or less got used to the arrival of these foreign dignitaries without quite knowing what was going to happen at any of them. Each was different. This time, although it was hardly more than dawn, what looked like every Centaurian on Tupelo was there before him. In the first rank he recognized Mrs. Brownbenttalon and her newly elevated daughter, Mrs. Whitenose. There might have been others he knew, but he couldn't pick them out in the mass of several hundred of the great females, with their smaller males and young romping around among them. When they saw Giyt they made way for him to join the other mayors in the front row, but he detoured as he caught sight of Hoak Hagbarth lurking by the portal.

"Hagbarth!" he called. "Wait a minute."

The Ex-Earth man had already hastily turned to take his place at the control switch, but he was blocked by a dozen Centaurian females crowding toward the portal. "Listen," Giyt panted, catching up to him. "I really need to talk to Dr. Patroosh."

"But she doesn't want to talk to you, Giyt."

"I'll believe that when I hear it from herself. Mind telling me where she is?"

"I do mind, and, listen, Giyt, even if I didn't, don't you think the lady would like to be left alone? Considering what time those poor people finally got to bed? Considering they got a full day's work ahead of them? Now would you please let me get this bunch in?"

There was no arguing with that. The Delt in the control group was already screeching furiously at Hagbarth to join them. Disgruntled, Giyt took his place in the rank of mayors. He hardly noticed when the chime sounded, the portal began to glow, the door opened and the four Centaurian VIP females, their husbands peering excitedly out of their fur, emerged. He was considering his next action. Perhaps Patroosh was staying at the Hagbarth house; he could go there and demand entrance—preferably before Hagbarth himself got there.

He didn't linger any longer than protocol absolutely demanded, but as he was heading for a cart a tiny Centaurian male scuttled through the crowd, calling his name. "Large Male Giyt! This is I here, principal husband of Mrs. Brownbenttalon, you recall me? Be waiting briefly, please!"

"I'm in kind of a hurry—"

"Yes, surely. Deeply regret interrupting, but esteemed wife ask me to inform you. You wish find Earth female Patroosh, she say, having overhear you talk with Large Male Hagbarth person, correct? She say good idea go see New Zealand Large Male. Thank you. Now must return instantly for completing of welcoming high-ranking co-species persons."

It took a lot of knocking and ringing to get anyone to answer the New Zealander's door, and when the man showed up, half dressed, he looked seriously annoyed. Even more so when Giyt announced that he wanted to see Dr. Patroosh. "Who the hell are you?" he demanded. "The mayor? Oh,

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right, the bloke that wanted to bring weapons into Tupelo. What the hell did you want weapons for?"

"It wasn't my idea. Can we talk about it some other time? I just need to see Dr. Patroosh."

The New Zealander looked suddenly suspicious. "What've you been hearing about her and me?"

"Nothing. I just need to talk to her."

The New Zealander studied him for a moment, then shrugged. "Well, why don't you come on in? I think she's probably out of bed by now."

So she was, but she was still wearing a wrapper over a frilly nightgown. It suited her, with her hair down; in fact, she looked quite pretty, and Giyt could see why doubling up had not been a hardship for the New Zealander.

She did not, however, seem pleased to see Giyt. "Yes?" she said frostily. And she remained frosty while Giyt told her his shadowy suspicions about Hoak Hagbarth.

The New Zealander was listening intently. When Giyt finished he said, "What've I always told you, Amelia? It was a mistake to let Tupelo be an all-American project."

Patroosh gave him a tolerant look. "But that's only temporary, Jemmy. America's where Ex-Earth has been getting all its funding, so naturally America has a special interest. But they say they're definitely going to open it up to the rest of the world real soon now."

The New Zealander gave her a skeptical look. "I think we ought to listen to what this man has to say."

"Ah, Jemmy," she said crossly, "don't you think we've got enough on our plate? We've got to bring up the question of exchanging ambassadors again, and that's going to be a long, hard fight."

"But it's important," Giyt put in.

She shook her head. "Listen, Giyt—" she began, and then hesitated. "Well," she said at last, "I guess you ought to know. Hagbarth's pretty down on you. Says he misjudged you. Doesn't think you're the right kind of person for the colony. And he has some stories about your wife—"

Giyt's expression hardened. "I know what he says about my wife."

"I don't really *care* what he says about your wife. But it makes a problem. If the Ex-Earth rep and the mayor are feuding, it complicates things here."

"But if the Ex-Earth rep is committing a crime—"

"Depends on what kind of crime it is, Giyt," she said kindly. "The UN can't do anything about embezzlement out here, can it?"

"I don't know that's what it is," he said obstinately. "It could be anything. It could be something that damages relations with the other planets."

"Yes, it could," she agreed, "but we don't know that, do we? As far as I can see, we don't know anything at all." She meditated for a moment, then sighed. "Giyt, I'll tell you what I'll do. When I'm back on Earth I'll ask Interpol a few discreet questions. If they know anything, I'll try to follow up."

Giyt, torn between knowing he ought to thank her, wanting more action: "When will that be?"

"A while. The ambassador-exchange

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thing is going to take time. Maybe a couple of weeks, even. But that's the best I can do. If you wanted me to do anything here you'd have to have more evidence. Now will you please leave us alone so I can get dressed?"

More evidence? All right, Giyt thought, I'll give her more evidence. And when he got back to his home he asked Rina, "Do you think you'd be all right by yourself if I went to the Pole for a day or two?"

XXIV

Welcome, welcome, and welcome to our wonderful visitors from good old Mother Earth! And a special welcome to our dear old friend, Dr. Emilia Patroosh, who we all fondly remember from her visit here just a few months ago when she came to investigate the problems with the new generator system planned for Energy Island. And I've got some really good news for everybody, because tonight's the night! Our own dear Hoak and Olse Hagbarth are having a cookout at their home and all six of our honored guests have graciously consented to be present to meet you. Everyone's invited! And I don't have to tell you that a grand time will be had by all when we partake of that famous Olse Hagbarth hospitality! See you there!

—Lt. Silva Cristl's broadcast

The decision to go to the Pole was made. Implementing the decision was harder. The first thing Giyt tried was polling the other mayors about revising the passenger list for the polar rocket.

He didn't get very far. The mayors weren't hostile, exactly, but they were clearly unwilling to get into a dispute between Earth humans. Even Mrs. Brownbenttalon was no help. "Could gladly give to you Centaurian seats if available, Large Male Giyt," she said, "but fact is got no Centaurians going this trip or not next trip either, too. Wait. I maybe try Kalkaboos."

What she tried was to call the Kalkaboo High Champion on her own to see if he could be got to turn a seat loose. That didn't work, either. Downcast, she reported: "New Kalkaboo High Champion no better than old Kalkaboo High Champion. Talk much. Do little. Say always permanently willing helping out good friend and assassin of predecessor who has made amends therefore, Earth Human Giyt, but not in this particular case. Say friend Giyt surely aware delegation of high persons from home planet presently present here and maybe would not be approving."

"Well, he could ask them," Giyt said.

"Certainly could. I spoke so also. He say not advisable, could cause problem. What sort problem he mean," she added, "is maybe home planet bosses might be annoy, could think stinky new Kalkaboo High Champion not as good as stinky old one. Stupid, you think? Sure. But what you going do? Is how Kalkaboos are, mostly. Now let me try Delts."

The Delts weren't helpful, either. When Giyt had to report failure to his wife she was warmly sympathetic. "Look on the bright side, hon. Here are all these people that aren't even

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human, and they do their best to help you—some of them, anyway."

"A very few of them," he grumbled. "And what the Delt said was that he'd do it in a minute, but the Slugs would have a fit because they're naturally scum, I hate the way these people talk about each other."

"Why? It's just talk, Shammy."

"It's not the kind of talk I'm used to," he insisted.

She sighed. "You've led a sheltered life, hon. When I was a kid in Newark Mom was always making little jokes about the drunken Irish and the dumb Poles, and we all talked mean about the Protestants, and we and the Protestants never had a good word to say about the Afros or the Asians. Didn't mean much. We kids all played together, and our parents all got together for the Fourth of July parade and the Christmas baskets for the poor. The eeties just talk that way, hon. They get along. They've been doing it for hundreds of years, you know, and never any big fights. Which is a lot more," she added ruefully, "than you can say about any of our countries back on Earth."

Giyt considered trying to stow away on the rocket—impossible—or just showing up at the launch pad and trying to bully his way aboard—just as impossible. Then he faced up to reality. He only had one alternative left. He had to swallow his pride and ask Hagbarth for help.

That wasn't easy, and what made it harder still was that he couldn't get Hagbarth on the screen; his personal access didn't respond, and when Giyt tried the one for the Hagbarth house it was jammed up. He would have to do it in person.

When he got to Hagbarth's house he saw what the problem was. The cookout reception for the delegates was in full swing. He had to abandon his cart half a block away, because hundreds of people were swarming around the house. As he tried to pick his way through the crowd he got surprised looks from nearly everyone, some uneasily reluctant to meet his eyes, some staring at him with frank loathing. He was still a dozen meters from the front door when Hagbarth himself came steaming up. "What are you doing here, Giyt?" he demanded.

"I want to go to the Pole," Giyt said.

Hagbarth didn't laugh. He barely smiled—well, "sneered" might have been a better word, though he spoke mildly enough. "Can't be done. Don't you follow the weather reports? They had this big blizzard at the Pole. They're still digging out. No time to have tourists."

"I'll take my chance."

"Well, Giyt, you won't. Not this time. There's no room on the rocket. Don't you pay any attention at the Commission meetings, either? You guys allocated us two seats, and they have to go to highly qualified technicians just waiting for a ride; we need them on duty there, Giyt. The factory might break down without them. Maybe next time."

"Which is when?"

"Well," Hagbarth said reasonably, "how can I tell? You never know when some of these home-planet people might take it into their heads to

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bump everybody and go up and take a look for themselves. Maybe next week. Maybe not. Now I've got guests to attend to."

In the end, it wasn't Hagbarth or any of the eeties he'd asked who gave Giyt help. It was Rina.

"Hon?" she said, coming into where he was bent over his screen again, sounding doubtful. "I don't know if it's such a good idea. It wouldn't be comfortable, that's for sure—"

"What wouldn't?"

"Well, my friend—you know, the Petty-Prime female, the one that's married to the horticulturist? You've seen her over here. Anyway, she says they've got space reserved for their whole family on the rocket. They're willing to wait. So, if you're sure you really want to go there. . . ."

XXV

The polar powerplant was primarily Delt, in both construction and operation. The mines were largely Kalkaboo, though the Centaurians and the Slugs had combined on the lab work that made possible the processing of the ores. The factories were everybody's.

In its original form the polar complex began with three structures, set at the vertices of an equilateral triangle. One of the structures is for the Centaurians, one for the Slugs, the third common to both for shipping and warehousing; it is near this third building that the landing and launch pad for the suborbital rocket is located. Two kilometers away is the dock for the robot submarines which carry heavy cargo to the island settlement. This is kept ice free by waste heat from the powerplant, though the structures themselves are often banked high with drifts.

Earth's single structure is one of four hived off from the original Centaurian structure, the other three being an additional dome for the Centaurians and two which are the property of the Petty-Primes.

—Britannica on-line, "Tupelo"

The opening session of the six-planet meeting wasn't scheduled to begin for nearly three hours, but a lot of the delegates and their staffs were roaming the town. In the cart to the lakefront Giyt saw clumps of them wandering around like tourists anywhere, taking pictures, getting souvenirs. Giyt wasn't paying much attention to them. His mind was concerned with the prospect of making a polar flight under the conditions the Petty-Primes' generosity made possible, while Rina wasn't looking at the visitors at all. She was withdrawn and worried. It wasn't until they were getting into the boat for the ride across to the launch pad on the far side of the lake that she glanced at the other passengers and said in consternation, "They've all got heavy coats, Shammy! You don't even have boots. It's winter up there!"

Giyt had noticed the same thing, but tried to reassure her. He wouldn't be out of doors at all, he promised. It didn't satisfy Rina. "No, Shammy," she announced, "you need somebody to take care of you. I'm going to come along."

She very nearly did board the ship

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at the last minute, as a matter of fact. Very likely would have done it, too, in spite of everything, if there had happened to be an available unoccupied seat in the Pole rocket.

But there wasn't. "No more seats, certainly none at all, definitely not any, no," the Delt at the door announced morosely. "Two seats remain open now for Earth-human persons, yes, but taken. Persons are late, too! Persons better damn come soon so captain get this vehicle back in time for watching of opening ceremonials, otherwise captain be damn mad!"

"I'll be taking the Petty-Prime space," Giyt informed him.

The Delt gave him the benefit of a concentrated stare from both eyes. "You what?"

"It's all right. The Responsible One gave his permission for the switch."

"Ho!" the Delt snarled. "Responsible One? Gave permission? That very sweet, but, tell me, is Responsible One perhaps person who must now have task of to remove Petty-Prime seating structures from vehicle, so as to make physically feasible space for person your volume and mass to occupy? Still more not to be forgiven injustice!" As he turned to enter to do the job he flung over his shoulder, "For female Earth human person, still no. Not possible at all."

Giyt turned to Rina. "So you see there's no room. But I'll be all right."

"Maybe so," she granted dubiously, "but also maybe not. What if these other people don't show? Then there'll be room, won't there?"

But that was a faint hope, quickly dispelled; the sound of a motor from across the lake was what dispelled it. A boat was speeding toward them, and as it was slowing down to touch shore Giyt saw who was in it. There was a driver, and two men huddled in parkas behind him. "*Damn!*" Giyt muttered. The men were Wili Tschopp and Hoak Hagbarth.

When the driver exited it turned out to be Olse Hagbarth, unctuously friendly. "Came along to see your hubby off?" she asked, chummy enough to make a cow puke. "Me too. Isn't that always the way for us wives? We stay home with the housework while our men go off—what? You go along with him? Oh, no, hon, you mustn't think about going along. Even if there was space for you. The acceleration in that rocket is *fierce!* Not so bad for a healthy man, maybe, but do you have any idea what it might do to that precious little baby inside you?"

Giyt's big fear was that his wife would punch Olse Hagbarth in the face, but she didn't. Rina allowed herself to be led morosely away across the charred surface around the pad, and Giyt hoisted himself into the entry door as the Delt mechanic brushed past him. He paused to speak to Giyt, half apologetic, half aggrieved. "Is now as good as can make it, which not in fact specially good, you know? You having nasty ride. Do not later speak didn't tell you so."

When Giyt tried to strap himself in he had to agree. The space intended for eight Petty-Primes was, in fact, large enough to hold an adult human male, but only if the human squeezed himself into the fetal position, knees almost touching his chin. As the Slug

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pilot came by, checking everyone's fastenings, he made a sound of reproach at Giyt. "Not proper stowage!" he slurped. "Can cause most grave discomfort in delta-vee conditions. Urgently you lie quite still in both ac- and de-celeration modes, otherwise potential for snapping of structural members. Not ship's. Yours."

Giyt prepared himself for the worst, his thoughts on this new development. What was he to do about the presence of Hagbarth and Tschopp on the suborbiter? They could have only one reason for this last-minute decision to come along. That was to keep an eye on him, and that he could not allow. He would have to lose them somehow. . . .

Then there was no more time to think. The Slug pilot extended himself to the front of the vessel—actually, in its present takeoff position, to its top. In the surveillance mirror over the pilot station Giyt could see the Slug taking his place at the controls. He didn't have a seat, exactly. All the other passengers, except Giyt, had custom-tailored sitting (or perching) places. All the pilot had was a sort of rubbery bowl.

As it turned out, that made good sense. The pilot didn't bother to warn the passengers when he started the engines. He didn't have to. Giyt heard the rolling thunder of the rockets beneath him, The craft began to shake. The noise grew louder until it was all but unbearable, and then the ship slowly began to lift. Then it picked up speed. . . .

That was when Giyt saw the wisdom of the form-fitting chairs. He knew perfectly well what *g*-forces were supposed to be like, because everybody did. At least, he had thought he did; but he had not expected how hard the platform he was resting on would become, or that his chest would be compressed until it was hard to breathe, or that the keycard in his hip pocket and the clasp of suspenders at the small of his back would suddenly feel like knives thrusting into his flesh. He could not see how the other passengers were faring, but in the overhead surveillance mirror he could catch glimpses of the Slug, now compressed into a sort of thick pudding in the bowl, his eyestalks pulled back into his body, a few tendrils stretched toward, but not quite reaching, the toggle controls.

Then the noise stopped.

The pressure was gone. The rocket was in the ballistic portion of its flight now, with no thrust at all, and no weight. Giyt took a deep breath, savoring the pleasure of breathing freely again. He glanced toward the passengers next to him, the pair of male Delts who were already twisting their heads to check the condition of their mates behind a pair of similarly packed Kalkaboos. Everyone was chattering away—incomprehensibly to Giyt, because somewhere along the acceleration the translation button had been pulled out of his ear by the *g*-forces.

While he was hunting for it he heard peremptory gurgling from the Slug and looked up. The pilot, restored to three dimensions, had hoisted himself out of his cup and was growling at Hoak Hagbarth. Who had unstrapped himself and was floating

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free, coming toward Giyt. "I know, I know," Hagbarth snapped at the pilot. "I'll get back when I have to." And then to Giyt: "Damn that Tschopp! He always gets airsick, and he never gets to the bag in time. Look at me!"

He was dabbing at his knee, where there was a definite smear of something on his pants that smelled nasty. Giyt could hear the sounds of Wili Tschopp busily vomiting in the seat just above him.

Giyt didn't answer him. He managed to stretch an arm to retrieve the translation button he had just spotted wedged into the back of Tschopp's seat. He didn't trust himself to speak. Hagbarth hesitated on his way to the toilet. "I guess you're wondering why we're here, with the six-planet meeting going on and all."

"Actually," Giyt said, "I'm not." And replaced the button in his ear as he closed his eyes. And didn't speak to Hagbarth again.

Coming back to the surface wasn't worse than the takeoff, but it wasn't appreciably better, either. If Giyt wasn't having the breath squeezed out of him quite as much, there was instead a whole hell of a lot more shaking and bouncing about as they reentered the atmosphere. Then the ship danced around a bit on its rockets as the pilot finally did in fact do a little piloting, making sure it was centered on the polar factory pad before he let the craft drop onto its massive shock absorbers for the last half meter or two.

Then they were there. They had to wait, strapped in their seats—waiting, Giyt supposed, while people outside foamed the ground the landing rockets had broiled. Then everyone began getting into their cold-weather gear—those that had it, anyway, which is to say everybody but Evesham Giyt. A moment later, responding to some cue from outside, the Slug pilot slithered down past the passengers, bulky in his rubbery cocoon of electrically heated fabric. He wrenched the door open and, without saying a word, left the ship.

Giyt took that to be permission to do the same. So did everyone else, all at once. Even after Giyt got himself free of the restraining gear, it took him a while to lever himself down through the tangle of other passengers and out into the shockingly frigid wind. The cold made him catch his breath, which actually hurt as it entered his lungs. It would have been even worse if it hadn't been for the foamed, but still hot, ground underfoot—

No, he discovered. It wasn't ground, and it wasn't foamed, either. What was underfoot was mud, soaked by the melting snow and cooked to a slurry by the landing rockets. It was still steaming, and it was ruining his shoes. They were in a sort of well surrounded by snowbanks, and meltwater was still gurgling away through culverts.

Someone had gouged out a series of planked steps to get them to the top of the snow, where a duckboard path led them to the waiting hovers. Giyt ran toward them, but Hoak Hagbarth ran faster. He was there before Giyt, panting and irritable, no longer bothering to pretend to be friendly. "This

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one," he ordered, pointing to one of the hovercraft. "Get in."

Giyt did as told; this was not the time to try making a break. A Delt followed him, then Wili Tschopp, morose and shaky from his airsickness. Giyt was shivering, too, his teeth chattering, but at least the car was relatively warm. The bad part of the warmth was that both Tschopp and Hagbarth, though swaddled in their bulky parkas, definitely stank. The Delt took one look at them with both his wandering eyes, then conspicuously leaned away from them as the car began to move.

A few hundred meters away, the factory buildings were bathed in light. Giyt squinted at them, trying to reconcile the remembered schematics of the polar complex with what was before his eyes. Most of the buildings were the familiar golden domes of Delt architecture, linked by their mole-run connecting tunnels, but what the car was heading for was a chunky, square-edged block, ten meters high but dark and windowless. That, Giyt realized, would be the central facility, from which all the others branched off. The car didn't stop outside, but went right through an air-curtain door without pausing.

Inside, they were in a bare room, corridors leading away from it in several directions. There was a sort of reception desk, untended except for a Delt technician, who roused himself from sleep to greet the Delt from the rocket. There was a distant thudding of heavy machinery in operation somewhere not too far away. Happily, the building was warm.

The two Delts disappeared in the direction of their dome while Tschopp and Hoak Hagbarth headed for toilet facilities—not the same ones, Giyt noticed—to clean up. "Wait here. Maury'll come and show us around," Hagbarth growled as he left.

That Giyt did not propose to do.

He looked swiftly around to orient himself. He knew that the Earth dome, as the latest built, was part of a necklace of two other domes, the Centaurians's and the Petty-Primes's. Since the factory plenum belonged to everybody, the wall readouts were in a wild variety of notations and languages. Giyt recognized the dancing curlicues of Petty-Prime script on one door and ducked into it. He hurried down the broad hall on the other side until he was almost run over by a pair of forklifts, one with a human driver and the other slaved to the first one—on the way, no doubt, to offload cargo from the rocket. "Excuse me," he called over the grinding whine of the forklifts. "I'm Evesham Giyt—the mayor, you know."

The driver was muffled in cold-weather gear, but his face mask was hanging loose from his helmet. "Really?" he said in surprise. "Still?"

Giyt disregarded it. "Am I going right for the human factory dome?"

The driver took his time about answering. "Shouldn't you be with somebody?" he asked.

"Of course not. I'm the *mayor*."

The driver brooded over that for a moment. "Well," he said, "most of the guys have taken some personal time. To watch the opening ceremonies of the conference, you know." He

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thought for a moment longer, then added doubtfully that he didn't personally get to the factory very often, but if Giyt wanted to keep going to the Centaurian control room there was a female there, stuck with the duty like himself, who might know the way. And who liked to gab. And, since the whole operation was of course automated, didn't have much else to do.

Giyt didn't hesitate. It wouldn't take Hagbarth and Tschopp much longer to make themselves presentable, and he didn't want to waste his best chance to get rid of them.

He found the Centaurian control room easily enough, and at least part of what the forklift driver had said was true. The Centaurian shift manager was curled up on a pad in front of the controls, lying on her side with her paws relaxed and displayed: three of them were white, the other the dun color of her fur. A wall screen was displaying the opening ceremonies of the six-planet meeting, but she wasn't attending to it. She was murmuring softly to the husband who was nestled in the soft fur under her chin.

They did not look as though they wanted to be interrupted. But the male was peering at Giyt with bright eyes, and when he whispered something to his mate she turned her snout toward the door. "What person are you?" she demanded.

"I'm Evesham Giyt. I'm looking for the Earth-human factory dome."

"You got visiting permission pass? No? You got no chance going that place alone, Large Male. You go away or I call—wait one." Her husband was whispering to her. Then she looked at Giyt in a different way. "Oh," she said. "You *Mayor* Large Male Evesham Giyt. You guy bitched up stinky Kalkaboo guy, right? Why had not spoken so right away?"

"That was just an accident—" he began instinctively, but she was still talking.

"Mrs. Brownbenttalon litter-sister of my junior husband here," she said with pride. "She say you pretty good guy. I also think it; damn Kalkaboos always getting damn feelings hurt. You want see Earth-human dome, sure, Mr. Threewhiteboots here take you, show you where everything located, no problem. But when you are got there, please, you tell him quickly hurry right back."

The little male took Giyt in a Centaurian cart—no seats, just a sort of pad with grips to hold onto—and when he had delivered Giyt to the human autofactory dome he didn't wait to be told to hurry back. He was quickly gone, to whatever intimate moments the couple had been heading toward.

There was a screen, and a door, but the door wasn't open. The human autofactory, of course, was locked.

Giyt could hear rumblings from inside. That meant nothing about whether anyone was there; the nature of an autofactory was that it was automatic. Likely enough anybody who was supposed to be on shift had taken off to watch the opening ceremonies of the six-planet meeting, like everybody else.

He flexed his fingers and sat down

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at the screen. There were not many combinations or passwords that could keep Evesham Giyt out, and it took only five minutes to establish that this wasn't one of them.

When he entered the chamber the rumbling sounds were louder. They came from where a cascade of the talking dolls were dropping out of the assembly machine onto a moving belt, to be picked up by the packing members and stowed in shipping cartons. Several dozen filled cartons were already stacked against a wall, waiting for shipment.

And none of that was of any interest to Giyt.

He looked around and found locked storerooms. Those looked more promising. Their locks, too, were only a small inconvenience. But while he was working out the combination his screen buzzed and half a dozen legends appeared on it. The one in English said:

Earth human Evesham Giyt has wandered away from his party. If you see him please inform Central Command of his whereabouts so he can be returned.

He scowled and picked up his pace; the communications would not remain so polite. One after another the locked doors opened. Behind the nearest one, in this warehouse where no one but humans ever went, was a store of Kalkaboo dawn-bangers—big, bomb-shaped firecrackers, of the size that required detonators. Behind the other doors—

Behind the other doors was worse.

There was no reason for any Earth human to possess Kalkaboo firecrackers, even little ones, to say nothing of these monsters. But the other things in the locked storerooms simply had no business existing on Tupelo at all. They were Earthside weapons, and there were hundreds of them. Handguns. Minicarbines. Assault rifles. Grenades. Even mortars; even shoulder-launched missiles, the kind that rocketed to an enemy's position and then exploded with a shower of high-velocity shrapnel. And when he looked more closely at the missiles he saw the answer to two puzzles.

The missiles bore sniffer vents. They would follow the airborne odor of a target and explode over the target's head, and that explained why there had been that almost forgotten data file on the scents of the eetie races on Tupelo.

And to make them work required high-tech computation . . . and that explained something, too. That had to be where the missing chiplets had gone.

XXVI

The story of human warfare can be told as the evolution of hand-held weapons. As the English longbow spelled the end of armored knights at Agincourt, the machine-gun marked the final defeat of the cavalry charge in World War I. The Second World War produced a temporary reversal, as the major weapons became the airplane and the tank, while the foot soldier could do little more than exploit the breakthroughs that air and armor made for him. But then came the hand-held anti-tank rifle, the flamethrower and,

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most deadly of all, the shoulder-launched bus. This was a missile that could carry any sort of weaponry—shrapnel, chemical agents, even mini-nukes. It would be programmed to explode at a given point or on detection of enemy troops, given away by their body heat, their sounds or even the aroma of their bodies. It could fire around corners and from concealment; it made the foot soldier the equal of a tank.

—Britannica on-line, "Weapons"

The thought came too late to be useful, but if he had thought of it in time it would have been no trouble at all, Giyt told himself, to have brought a microcam along. He could be photographing the whole thing. Then he could be taking it to the people at the six-species conference, there to blow the whistle on whatever foretaste of hell Hagbarth and his buddies were planning for Tupelo.

But he had no camera. What then?

There was plenty of evidence here. The trouble was that it was all too big to carry. He needed something small enough to hide on his person. There was no way he was going to get onto the return rocket—past Hoak Hagbarth—if he was carrying a shoulder-launcher or a carbine, much less one of the Kalkaboo bombs.

Thoughtfully he pocketed a Kalkaboo detonator, but that wouldn't prove anything; there were multitudes of them on sale in the Kalkaboo store in the town. What else? There was no ammunition visible for the minicarbines, but the assault guns were loaded; he slipped a clip out of one of them and stowed it away.

Then he tackled one of the buses. If he could take one of them apart to get its chiplet out, that would remove all doubt. On Earth there were plenty of experts who would be able to read the programming on the chiplet, and that would show just what the thing had been built to do.

Figuring out what had to be done was easy. The execution was a lot harder. The damn thing wasn't meant to be disassembled. Worse, he had no tools. There probably were tools somewhere around, maybe in the same place as the ammunition for the minicarbines, but he didn't know where that was. So it would have to be a simple smash and pry operation—with the added worry at every step that if he hammered a tad too hard he might detonate the explosives and fuel in the bus. Time was a problem that couldn't be ignored, too. Sooner or later Hagbarth and the others would be checking the factory in their search for him. By then he had to be elsewhere, and ready to give them some kind of lying apology for going off on his own . . . and hope they bought it . . . and then—if, against the odds, he had been lucky enough to get away with that much—somehow manage to get back on the suborbital rocket's return flight with his booty intact.

He didn't quite see how he was going to manage any of that, but meanwhile he had the present job.

Wonderfully he managed to get two of the buses open enough to fish out the chiplets, all the while rehearsing—and rejecting—the things that

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he might say to Hagbarth. Anyone who looked at the two buses would see they had been tampered with. For what good it might do he put them at the back of the stack. Then he locked all the storeroom doors, erased his programs from the screen, let himself out and relocked the door, and started back down the hall.

He didn't get far before he heard the whir of an approaching cart, and, of course, it was Hagbarth.

Hagbarth wasn't alone. Tschopp and that other man from the fire company—Maury Kettner?—jammed the cart beside him. They all leaped out as soon as the cart had stopped, scowling angrily at Evesham Giyt.

"Jesus," Giyt cried enthusiastically, "am I glad to see you guys! This place is wild. I finally did find the factory, but the damn thing's locked up."

Hagbarth studied him thoughtfully without speaking. He gave Maury Kettner a nod; the man turned and walked away as Hagbarth said, "So you were just wandering around, is that what you're saying?"

"Trying to find the factory," Giyt agreed, doing his best to see where Kettner was going; afraid he knew the answer in advance, but seeing no choice but to tough it out. "This is a very confusing place, Hoak."

"Of course it is. Why didn't you wait for us?"

"Well, you took so long," Giyt improvised, looking over his shoulder. Kettner had opened the factory door and disappeared inside. He was taking a long time in there, though. Had Giyt left some sign of his entrance? "Anyway," he added, "I ran into a couple of eeties, and they gave me directions."

"But when you got there it was locked."

"Locked, right," Giyt agreed.

Hagbarth nodded, poker-faced. "Was there any special part you wanted to see?"

"Oh," Giyt said, shrugging vaguely, "just to get a general idea, you know? So I'll know what I'm talking about when I see Mrs. Patroosh."

"She's a busy woman, Giyt. You don't want to bother her with a lot of unimportant stuff."

"No, of course not," Giyt agreed. "It's just that . . ."

But his voice trailed off. The factory door opened. Maury Kettner came out, and his expression was cold. Worse than that, he was carrying one of the carbines from the store, and Giyt observed unhappily that Kettner, at least, had known just where to go to find its ammunition clip.

He was staring at Giyt, but it was to the others that he spoke. "He was into the stash, all right," he said. "The seals were broken."

Hagbarth exhaled a sigh. "Ah, Giyt," he said reproachfully, "what did you do that for? More important, what are we going to do with you now?"

It was a rhetorical question. If aimed at anybody, it was at Evesham Giyt; but it was Wili Tschopp who answered it. "There's always the Heckslider way," he mentioned.

It took a moment for Giyt to make the connection, and then Tschopp spelled it out for him. "You know

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about Harry Heckslider, don't you? The one who fell out of the chopper on the way to Energy Island. See, he got curious, and he just wouldn't listen to reason."

"Now, wait a minute," Hagbarth said good-naturedly. "Why do you think Evesham here would be like that? You don't have any special love for our alien brothers, do you, Evesham?"

Hagbarth's tone was friendly enough—no, Giyt decided, a lot too friendly. The man was putting him on. He said, temporizing, "I've got nothing against them."

"Really? Not even the Kalks?"

"Well, I thought they gave me a lot harder time than was called for—"

"Damn right they did! I really hated to see them working you over like that, Evesham. Not that the others are all that much better. Can't ever trust any of the freaks, that's what I say. You know they've all been scouting Earth for years, don't you?"

Giyt was honestly surprised. "Scouting Earth?"

"You bet! They've got their ships orbiting the Sun, watching us, learning everything about our capabilities—how do you think they got that portal to Earth so fast?"

"Why, I guess I never thought—"

"No," Hagbarth agreed bitterly. "You never did think. Most people didn't, but there they are, and you know what kind of weapons they've got, because your Centaurian friend told you all about their old wars." He was breathing heavily. He collected himself and spoke more reasonably. "Anyway, Evesham, you're a patriotic guy, aren't you?"

I am? Giyt asked, but not out loud. Actually he didn't know the answer. He had never given much thought to patriotism, but now . . .

Hagbarth was going right on: "I mean, you know what the score is. The freaks would do us in in a minute, if they had the chance. What do you think the Kalks have all those big explosives for? And the Delts have those harpoons—think they don't think of using them on the rest of us now and then? And what do we have?"

"Well," Giyt said, pretending to think it over, "I guess we have those water cannons."

Hagbarth grinned at him, then turned to the others. "See? I told you he wasn't so dumb. But that's just piss-ant stuff, the water cannons. They couldn't really save us if the freaks tried a coup. That's what we need the other stuff for, right?"

Giyt gave another imitation of a man trying to work a hard question out. "Maybe you're right," he admitted. "One thing that kind of puzzles me—"

"Yeah?"

"When you got me to try to get some weapons imported. Was that just so no one would think you already had some here?"

Hagbarth grinned and clapped him on the shoulder. "Smart," he said admiringly. "So how about it, Evesham? You won't say anything to anybody about what you saw, will you?"

"I guess not."

Hagbarth patted his shoulder again approvingly. "That's good, Giyt. Glad to have you aboard. Just to make sure, you won't mind if we search you, will you?"

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Giyt let out a long breath. He was not a violent man, and there were three of them. There was no way he could stop them if they wanted to search.

"Oh," he said, reaching inside his tunic. "You mean you'd be looking for something like this?" And he took out the Kalkaboo detonator and displayed it, wondering if they were too far from the bombs for it to work.

"Hey!" Tschopp yelled. "Careful with that thing!"

Giyt was careful. He pressed the button firmly and with care; and, as it turned out, they weren't too far away at all.

XXVII

The segregation of industrial facilities at the polar installations is not only dictated by political considerations—each species has its own private workplaces—but is a safety measure. The passages connecting the domes are secured with blastproof doors. In addition, the Delt-designed roofs, though massive enough to withstand any snowload likely to occur in this region, are deliberately designed with fault lines so that, in the event of an explosion, most of the force of the blast will be exerted upward. This is deemed necessary in case of accident, but no such accident has ever occurred.

—Britannica on-line, "Tupelo"

Giyt could see that Hagbarth's mouth was moving. That was how he knew that the man was saying something, or, from his expression, most likely furiously bellowing something, but what Hagbarth was bellowing was drowned out in the thunderous crash and rumble from the doll factory. Giyt saw that the door to the factory was bulging toward them. For a moment he thought it would fly open, but it didn't; it swelled and shuddered, but it held. As the echoes of the explosion died down Hagbarth gave Giyt a petulant look. "What the hell have you done *now?*" he asked, and didn't wait for an answer. With Kettner he raced to the door and tried to pull it open. It resisted. Kettner set down the minicarbine to get a better grip on the door, while Tschopp was staring after the other two, open-mouthed incredulous and scarlet-faced angry.

Even a nonviolent man can find a little violence in him now and then. Giyt didn't pause to think. From behind Tschopp he kicked at the back of the man's knees. As Tschopp went sprawling Giyt was already running, as far as he could get from the men with the guns—down the corridor, around a turn, through an open door, down another short hall.

The hall ended in a doorway with a glowing orange sign over it. The sign was in the curlicues of the Delt language, but Giyt knew what it was: That door went to the outside world.

He paused for the fraction of a second to consider. Did he want to go out into the freezing polar night again? Did he have a choice?

Put that way, it was a simple decision. When he grasped the handle it was cold to the touch. When he pushed the heavy door open the blast that came in was colder still. He hesi-

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tated, thinking about just what it was going to be like to be out, dressed as he was dressed, in that fierce Arctic gale; but he knew the others were not far behind him. Outside, at least, the dark might hide him.

He stepped through, hugging himself against the freezing blast, and let the door close behind him.

That was the first disappointment. It wasn't really that dark. Overhead the colors of the aurora washed across the sky, rust-red and pale blue; they weren't bright, but they were widespread, in places obscuring the icy bright stars. It was light enough to see by, surely. If Hagbarth and the others followed him out they could pick him out in a moment, and then—

Then it would be very bad for Evesham Giyt.

He floundered to where the winds had scoured away most of the snow and began to run. His lightweight shoes crunching against the gritty crust left from some earlier snowfall, his feet already feeling as though they were beginning to freeze. He expected at any moment to hear shouts from behind him, and then, no doubt, the pippity-pop of the minicarbine. Or did you ever hear the shot that got you? Weren't the bullets moving faster than sound? So perhaps he would hear nothing at all, but he would feel something, all right. What he would feel would be the punch-punch-punch of a dozen rounds from the minicarbine stitching themselves across his back . . . and that would be the last thing he ever felt, in the moment when life would come to an end for Evesham Giyt.

The second disappointment was that there was nowhere to hide.

Giyt thought wildly of clawing out a foxhole in the snow, maybe covering himself with the stuff. Not for long. Even assuming it was possible, assuming he could do that with the bare hands that were already stiffening up, he knew what would happen then. Either they would find him anyway, or he would freeze to death.

What he was doing was making it easy for Hagbarth and the others.

They weren't likely to shoot him. Why bother, when shooting him meant they would have to explain away the bullet-holes? While if they simply left him alone he would die of the cold. He could hear what Hagbarth's semi-pious explanations would be: "I guess the poor son of a bitch must have done something stupid that caused the accident, you know? And then he ran away, probably trying to hide, maybe in shock or something, and then he must've got outside somehow. It's really too bad, and I'm going to hate having to tell his wife, but, Jesus, look at the damage the bastard caused!"

To have any chance at all of surviving Giyt needed to get back to the warmth inside. He looked around wildly, each breath a separate hurtful thrust of pain in his nostrils. Instinctively he had been running back toward the rocket port, to the building just ahead that had to be where Mrs. Threewhiteboots and her mate were overseeing the instruments at the plenum. . . .

There had been a door there, he remembered.

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There was, and just by the door, parked, was a Centaurian hovercar. He tried the door of the car, but it was locked, and his fingers were getting numb.

Perhaps the Centaurians could help? If he could get the door to the plenum open from outside. . . . As it turned out, he couldn't. There was no external handle and not even anything to grip and try to pull it open.

But when he had hammered on it long enough, freezing, despairing, it opened a crack and a long Centaurian snout poked inquiringly out to peer at him.

It was hard enough for Giyt to try to explain what had happened, his limbs numb, his teeth chattering, and it must have been even harder for the Centaurians to comprehend him through the vagaries of the translation program. But Mrs. Threewhiteboots was quick to understand. "Damn right," she said. "Something require being done. Never liked that stinky Large Male Hagbarth—no offense other Earth humans, all right? So, OK, we hide you someplace. Warm you up. Come."

As it turned out, not all the tiny doors were for Petty Primes; Mrs. Threewhiteboots held one open while her husband scuttled ahead, clucking and mewing to the chorus of tinier clucks and mews that came from inside. A door that was built large enough to allow passage for a Centaurian was not meant for humans, but Giyt somehow managed to bend his stiffening body low enough to squirm through.

At least it was warm inside the Centaurian lounge. It was dimly lit, and it also smelled quite horrible, likely because of the half dozen pups that were squirming around one of those elevated Centaurian sleeping pads. "New litter," the female said proudly, cuffing them out of the way. "Exceptionally handsome lot, don't you agree? Now you come closer here, I hug you to defrostedness."

Her fur was soft, her body blessedly warm. The pups didn't like the idea of this alien monster preempting their mother's embrace, but the male spoke sharply to them and they curled up sullenly against Giyt's back. When he tried to talk she shushed him peremptorily. "You get blood running again, then have conversation. Not yet." But then, as he felt life returning, he felt also a nearly overpowering urge to drift off to sleep. He resisted it; his story could not wait. Haltingly he told Mrs. Threewhiteboots what he wanted to do.

"You bet, sure," she said. "Show proof to six-species gathering, good idea. So we take you to rocket, all right, let damn ugly Large Male Hagbarth try to stop us."

"But he has a gun," Giyt remembered to say, between bouts of yawning.

That produced a considerable silence. Then Mrs. Threewhiteboots murmured something to her mate, who turned and pushed his way out of the door. "Hate damn guns," she said morosely. "That make things tough, right? But we do best we can. Mr. Threewhiteboots go check things out. Now you sleep a little, understand me?"

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It was an invitation hard to refuse. Against his better judgment Giyt let his eyes close. Perhaps Mr. Threewhiteboots would come back with help. Or perhaps he would raise the alarm, and the several dozen other persons in the polar complex, human or otherwise, would turn away from the opening ceremonies long enough to overpower Hagbarth's few and convoy him to the rocket, and then to the Hexagon to show his chiplets to the council meeting. . . .

But perhaps Hagbarth would not want to be overpowered.

And he and his bullies did have that gun.

The gun made all the difference.

Of course, Giyt reasoned, it would make no sense for Hagbarth to start a shooting war here and now. Everything was against it. Hagbarth wasn't ready for anything like that. Especially right now, with the six-species council in session, and capable of summoning quick reinforcements from the parent planets. Most of all, Hagbarth's illicit armorarium had vanished with the explosion of the Kalkaboo bombs. Shooting anybody would certainly not be a sensible thing to do.

But, on the other hand, who had ever described Hoak Hagbarth as sensible?

A sudden twitch of alarm from Mrs. Threewhiteboots made Giyt open his eyes. That was a strange sensation, for what he saw was no different either way. Eyes closed, eyes open, there was only blackness. Was this what blindness felt like?

But it wasn't his eyes that were at fault. "Is power out," Mrs. Threewhiteboots said worriedly. "Power never out. Is bad thing. You stay here inside where no one can see, Large Male Giyt. I look."

That was an order he could not obey. As she peered out of the door Giyt was shoulder to shoulder with her. Power was out, all right. The principal illumination in the corridor was from one distant, palely glowing panel of green emergency lighting on the ceiling. He could see the plenum at the end of the hall, but the brilliant readout displays were gone, leaving only one fast-moving line of symbols on one wall. There were brighter moving lights just beyond there, too. Someone—no, several someones—were there with pocket torches, And he heard voices.

One of the voices was raised in anger, and it belonged to Hoak Hagbarth.

Mrs. Threewhiteboots moaned something, then reared upright to peer down the hall. Something small was skittering rapidly toward them. It turned out to be her mate, who leaped into the fur of her back, chattering at her. She listened for a moment, then turned and shoved Giyt back inside. "They coming, maybe! Go in! Close door!"

The power was out, and so were communications. Mr. Threewhiteboots (his mate explained to Giyt) had gone to the communicator; but that was when the power went. While he was trying to get the emergency circuits working to sound the alarm two large Earth-human males had come in. "They asking you, Large Male Giyt,"

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the female reported. "My husband hear you name, but nothing else; he not have translator. They talk at him, but he not understand nothing. Then they point stinky gun at him. He run."

"*Hell,*" Giyt said. Communications dead, access to the rocket blocked: Was there any way out of this? He thought rapidly. "Are they still there?"

"Think not. Don't want to look. You want?"

"No. Well, maybe I do, but not right away. They won't stay around. Then maybe I can—"

But he stopped there, because he knew, before he said it, that they would never let him get to the rest of the complex. They would let no one in or out until they had made sure Giyt was not still inside.

Then he remembered what was parked by the outside door.

He took a deep breath, then opened the door a crack, listening. The Centaurian pups were whining softly, but he heard nothing else, and it was dark outside. When he poked his head out there were no lights.

There would be no better chance than this. "Mrs. Threewhiteboots," he said, "do you have a keycard for the hover? If I could get around the outside to the rocket pad—"

She made a snuffling sound that might have been amusement. "What you do with keycard? You think you driving Centaurian hover?"

"Maybe you could tell me how to do it."

"Maybe you being very ridiculous, Large Male Giyt. Never happening; driving instruments quite complicated. Also what you think those large males do, they finding us here and you gone? No. Not giving keycard. Driving vehicle own self, most fearfully."

Mrs. Threewhiteboots delayed only to scrabble in a compartment for a body-shawl and a set of flat disks like snowshoes. When she had strapped them to her little feet she muttered to her husband and led the way to the door.

The hovercraft started quickly and moved easily over the drifts. It took only a few minutes to reach the rocket launch pad.

And then they stopped, looking at each other, looking back at the dome they had left. There were more of those hand-held lights moving around there. They looked like they belonged to human beings—did belong to human beings—undoubtedly belonged to some of Hagbarth's people, searching for them. If they went back there they would be caught.

But there wouldn't be much point in trying to do that, anyway. The pad was empty. The suborbital rocket itself was gone.

XXVIII

With heartfelt sadness I have to tell you all, dear friends, that there isn't any doubt any more. Our mayor, Evesham Giyt, was definitely lost in that terrible explosion at the Pole.

So, folks, I think it's time for us all to show what big hearts we have here in Tupelo. Never mind that the explosion was his fault. Never mind what it's going to cost us all—many months of lost production, and I don't even want to think about how

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much money. Say nothing mean about the dead and gone, folks, no matter how much of a mess the guy made. Probably he just didn't know any better, maybe. So let's forget that part of it and just give our deepest sympathy to his grieving widow—who, you know, is probably going to be leaving us herself before long.

—Lt. Silva Cristl's broadcast

When Rina was awakened with the word that Giyt was missing and presumed dead she didn't believe it. Wouldn't believe it. And then, when she accessed the Earth-colony news channel, had no choice but to believe it, because the scenes of destruction from the Pole were too terribly convincing to be denied.

In the view from outside, the Earth autofactory dome was split completely open, oozing black smoke into the dark polar sky. In the view from inside everything was simply wrecked. Rina sat quietly in front of the screen, sometimes remembering to eat a bit of the breakfast she had absently made for herself, sometimes simply sitting motionless, not even thinking. When the news items began to repeat themselves she switched to other files, her lessons, her household reminders, sometimes Giyt's own files . . . but that was painful; because he wasn't there.

Lupe was the first to arrive at the house. "Oh, Rina, hon," she said, her voice as mournful as her face, and stopped there because she had nothing to add. She sat quietly next to Rina, holding her hand. Then it was Matya, with the younger children, the others busy getting themselves off to school. Matya was more businesslike, and full of news. The six-planet meeting was convening early to discuss the accident. The loss of life, at least, had been small—two eeties missing and supposed to have been caught somehow in the blast. And Giyt. The suborbital rocket had made an emergency flight to the Pole, bringing twelve Earth firemen to help control the damage, and was already on its way back for more. The economic consequences for the Earth community were worrisome; until the autofactory could be rebuilt everything would have to come by portal from the home planet. As would everything needed for the rebuilding; the Earth delegation had already sent a message back to Earth to say what had happened and that emergency help was needed.

Rina listened to it all politely—having, of course, already heard it all for herself on her screen—until Lupe finally gave up trying to force food on her, and Matya insisted that she go back to sleep. It was easier to pretend to obey than to argue, but Rina knew that sleep was impossible.

Well, not quite impossible.

Rina had taken it as given that she would lie wakeful in the bed that still bore traces of Evesham Giyt's friendly male odor, while horrid thoughts recirculated through her brain. However horrid, they needed to be thought anyway: Should she stay on Tupelo? Go back to Earth? Bear the child that was just beginning to stir inside her? Abort it?

All of those unpleasant thoughts had subsidiary thoughts, just as unpleasant,

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that followed instantly from the first: wondering about what life would be like as a single parent (or about what childless life would be like if she aborted the one thing she had left of Evesham Giyt). And what should, or could, she do about Hoak Hagbarth?

They were ponderous thoughts that would keep anyone awake; one way or another. They were all attempts to discern whether she had anything left that was worth the trouble of going on living for, and the first she knew that she had gone to sleep after all was when Lupe touched her shoulder to wake her. "It's Mrs. Brownbenttalon," Lupe whispered. "She just wants to pay her respects."

Actually the Centaurian female had brought more than sympathy. She hadn't come alone; with her was a nearly grown female, painfully lugging two large packages wrapped in green fabric. "This shade of green our frequency devoted to sadness," Mrs. Brownbenttalon explained. "Contents of package food and drink. Hey, everybody know have no time for cookery with death in family. You meet my third daughter, Miss Stubnose? You say hello, Miss; good, now go back home." She crawled up onto a couch, and acknowledged introductions to Lupe and Matya. "Yes, very sad happening," she agreed. "Have serious pain in abdomen, right here where husband mostly hang, for you, Mrs. Large Male Giyt. You main husband damn good son of a bitch. You know I also lose close family members in cataclysmic event?"

That took Rina by surprise. "You did?"

The matriarch bobbed her long snout mournfully. "Esteemed wife of male littermate Mrs. Threewhiteboots gone missing, perhaps caught in blast, also secondary husband of same. No trace found, damn Hagbarth claims must have been trespassing in Earth factory at accident time. Untrue. Mrs. Threewhiteboots never waste personal time in dumb Earth human factory."

"Oh, I'm sorry. . . ."

"For what? It not you guilt," Mrs. Brownbenttalon sighed. "Simply accident, surely. Reason I sorrowing, six babies of littermate's esteemed wife now orphans, very sad. But," she added strongly, "remember I still friend; you need any kind help you ask."

"Thank you," Rina said. "I think Lupe's making tea, would you like some?"

"Earth tea?" Mrs. Brownbenttalon pondered for a moment. "Sure, why not? Only why is Earth female Lupe waving at you in this fashion?"

The reason Lupe was trying to attract her attention turned out to be something on the kitchen screen, and when Matya turned on the one in the living room the face was Hoak Hagbarth's, being interviewed by Silva Cristl as he got off the rocket at the pad. "—Total devastation," he was saying to the interviewer. "No, we don't know *what* the hell Giyt did, but somehow he blew up the whole damn factory; God knows how long it'll take to get it running again. And it's dangerous up there, so Chief Tschopp has ordered half the fire company to the Pole to prevent any further loss of life. Giyt? Oh, he's dead all right, missus. He probably got

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blown up in that blast, I don't know if we'll ever find the pieces. But if he didn't maybe he staggered out into the snow, and then he just froze to death." He shook his head. "The damage is just unbelievable, but you know what is the worst part of it? It's the way he left his poor widow and their unborn child—"

That was more than Rina could take. "Turn the bastard off," she said, her voice shaking with anger at the man. But the fury she felt had one good quality. It told her that she did have one definite thing to go on living for.

When she was finally alone she considered how to set about her simple plan. If she couldn't bring Giyt back, at least she could avenge him.

What was hard to see was just how to go about doing that. Giyt, damn the man, had not left a clear record of what it was that he knew or guessed. There were any number of items in his files that provided clues—a tabulation of chiplet imports paired for some reason with the shipping records of finished products; a log of failed attempts to access the ongoing processing data from the Pole; scraps of files that might have meant something, but without Giyt there to explain their relevance were simply puzzling. There was even a just-arrived packet of data from Earth that was directed to Evesham Giyt himself, but it was encoded. Perhaps there was something interesting in that, provided it wasn't just a financial statement from one of Giyt's half-dozen money dumps.

The trouble was, Giyt wasn't there to provide the key.

It was high noon, then it was dark, then it was light again. When Rina could not stay awake she slept for a while. Then she got up and made the bed, so that company wouldn't think her a slob. And there continually was company, usually Lupe or Matya coming by every few hours, and staying until she somehow managed to get them to leave again, usually by pretending to be sleepy—and often enough actually going to sleep. And getting up. And making the bed again. And repeating the process. She picked up things in one place and put them down in another, made herself meals but couldn't always make herself eat them. She switched on the news channel: raucous times at the six-planet meeting as the eetie delegates joined in deploring the sloppy precautions the Earth humans had provided at the Pole; warnings that there would be shortages of some consumer items until new shipments could be received from Earth, coupled with appeals to refrain from buying anything not urgently needed during the emergency. She watched only as long as her interest was held—not long—and then she turned the screen off again.

If she had some technical help, she thought, absently rubbing her belly, she might be able to piece together whatever it was that Giyt had learned.

But help from whom? Was there anyone she could trust? Or would anyone she asked for help be just as likely to be part of the problem?

But she could not let Hagbarth get away with whatever he was up to.

So Rina sat down before the screen again and attacked the problem of de-

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coding the data packet from Earth. It had been a long time since, under Giyt's tutelage, she had done anything of the sort. It was like riding a bicycle, she found. Once she got started she remembered the skills Giyt had taught her. She set up a program to try every possible password, feeding in every word she could imagine Giyt including.

It took a while, but the program ultimately produced the password, which turned out to be "I guess I love Rina."

She cried at that, but only for a bit. Then grimly she began to study the packet.

And it was all there.

Ex-Earth was a front for an American expansionist conspiracy that reached up into high levels of the administration. They were planning to take Tupelo over. The autofactory at the Pole had been secretly manufacturing weapons.

Rina sat back, considering. Then she called Mrs. Brownbenttalon. "It seems that I do need help," she said. "Can you get me into the six-planet meeting?"

It was the first time Rina had been in the Hexagon since it was rearranged for the six-planet meeting. The six little platforms for the members of the Joint Governance Commission had been replaced with a cluster of seats (or pads or trees) to accommodate the high officials from the home planets; there were from six to a dozen members of the appropriate species in each position, with most of the floor space given over to their staffs and experts. It was *crowded*. And, as they were all talking at once, it was also hopelessly noisy. Rina's translator button struggled valiantly to render scraps of the other languages into English for her, but it was unequal to the task. What came out was a sort of chowder of half-sentences and expletives, and she finally took the thing out of her ear. It eventually took the best efforts of the chief Centaurian delegate, Mrs. Oneeyewanders, a female so august that she had not one but three husbands scuttling about in her fur, to restore something like order. When she screeched for quiet the rumblings of the crowd simmered down enough for Rina to finish her testimony. And all the while, there were the Hagbarths standing in the little cleared space next to her, giving her poisonous looks, shaking their heads.

Poisonous looks were all they could manage. It had not been smart of Hoak Hagbarth to send all his fellow-conspirators in the fire company to the job of cover-up at the Pole, because the ones that were left behind were not part of the conspiracy. Behind the Hagbarths stood a pair of the brawniest fire police left on the island, and neither of the Hagbarths dared move.

Then Rina accessed Giyt's decoded packet from Earth, and everyone was still, or nearly still apart from indignant whisperings to each other, as the record unrolled.

When it was over Dr. Patroosh was the first to speak, glaring at Hagbarth. "You *scum*," she said.

Then the Swiss chimed in—speaking in French, Rina guessed; but her translator had not been equipped

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with French language capability and so she could make nothing of it until the New Zealander spoke up. "I agree completely," he said. "We will all transmit this complete record to our governments at once."

"But it is all lies!" Hagbarth burst out. "She made it all up! Are you going to take the word of a whore against me?"

But they were taking it. Rina got the button back into her ear again in time to hear Mrs. Oneeyewanders speak up for her; so did the Slug, on what grounds Rina could not imagine. Then the Kalkaboo piped up: "Exists here no problem believing statement of Earth human female. Can make factuality check, surely. Immediately we can order stop to present cleanup at the Pole, then quickly dispatch six-species delegation up there for total discovery of truthfulness."

It was the most sensible thing Rina had ever heard from a Kalkaboo, and it had its effect on Hoak Hagbarth. The man wilted before her eyes. He gave Rina an imploring look, while his wife, sobbing, clutched at his arm. But if he wanted to speak he had no chance; the whole assembly was talking at once again.

So it was over.

The accumulated fatigue of the last few days struck Rina then; she looked around for a place to sit down, failed to find one, squatted on the floor, her head bowed. It was a moment of triumph, but she couldn't feel exultation. It only meant that now she had to face up to the real questions of life continuing without the presence of Evesham Giyt.

She didn't even notice that the assembly had quieted until one of the fire police poked her. She looked up.

The Principal Slug had slithered his way to the delegates' platform, clutching his pocket screen; he was showing it to the Slug delegate, who looked, and raised his forebody to speak. As Rina hurriedly replaced her translator he was saying, "—interesting news from ship terminal at dam. Unscheduled robot sub has arrived at terminal with passengers. They are three. Are hungry, cold, very, very dirty, but not in the least dead."

XXIX

URGENT. ACTION REQUESTED.

Access attached files 1 (data secured by Evesham Giyt) and 2 (statements of Hoak Hagbarth and Olse Hagbarth in Inter-Species Conference).

Urgently recommend immediate full-scale investigation of Extended Earth Corporation and all persons named in accompanying files. If allegations in attached files are supported, further recommend indictments for conspiracy to initiate military action on Tupelo, in violation of existing compacts. By unanimous decision of all five other species involved all sessions of the conference are suspended until this matter is resolved.

—Tupelo Delegation Dispatch to UN

As their boat raced across the lake to the dam. Lupe on one side of her, Mrs. Brownbenttalon and her husband on the other, Rina at last let herself cry. Mrs. Brownbenttalon examined the process with interest.

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"Leakage from eyes indicates sadness, I have information," she called, over the whine of the motor and the rush of the air. "This leakage not necessary, Mrs. Large Male Giyt. You husband alive OK; he remember robot sub can take home as easy as rocket, only slower. Like I say, he damn good son of a bitch, smart too!"

At some point, Rina told herself, she should explain to Mrs. Brownbenttalon that there were such things as tears of joy. Not now. Now she was fully concentrated on peering ahead at the dock area, looking for the person she most wanted to see in all the worlds. There were Delt technicians supervising the hoisting of cargo from the base of the dam to the lakeshore; there were Slugs watching the proceedings with a proprietary air—well, the ship terminal was in Slugtown. But it wasn't until the boat had actually pulled up to the shore that she saw the hoist coming up again, and this time bearing two figures—well, three if you counted the little one poking his snout out of his Centaurian mate's fur. Beside her Mrs. Brownbenttalon squealed and rushed to greet them, but not so fast that she beat Rina to the scene.

And then they had each other in their arms—Giyt shaky, dehydrated, dirty, but entirely *alive*. "Shammy, Shammy," she whispered in his ear. "You scared the shit out of me."

"I'm sorry," he said, sounding as though he meant it. "I couldn't figure out any way to let you know I was all right without letting Hagbarth know, too. Now let's get back to town. They were making munitions up at the Pole! I've got evidence that'll prove it—"

"I turned it over to the council already," Rina told him.

"—And I have to get it to— You *what?*"

His mouth fell open as Rina explained what had happened. Then he shook his head, looking at her wonderingly. "Jesus, woman," he said. "Looks like you're perfectly capable of getting along just fine without me."

"Why," Rina said with satisfaction, "I actually never doubted I could. I just don't want to." ■

You must not feel envious of anyone; for while good men deserve what they have, the bad live badly, even if they are prosperous.

—Apollonius of Tyana

When representatives of two completely different realities meet, words like *normal* become relative.

—Wade Davis

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THE REFERENCE LIBRARY Tom Easton

The Return, E.C. Tubb, Gryphon Books (Gryphon Publications, P.O. Box 209, Brooklyn, NY 11228), $20 (tp) (ISBN: 0-936071-83-4), $40 (signed, ltd ed.) (ISBN: 0-936071-84-2), 194 pp.
Greenwar, Steven Gould and Laura J. Mixon, Forge (TOR), $24.95, 381 pp. (ISBN: 0-312-85261-4).
Secret Passages, Paul Preuss, TOR $23.95, 381 pp. (ISBN: 0-312-86346-2).
Einstein's Bridge, John Cramer, Avon, $23, 354 pp. (ISBN: 0-380-97510-6).
Giant Bones, Peter S. Beagle, ROC, $11.95, 269 + xii pp. (ISBN: 0-451-45651-3).
Spec-Lit No. 1, Phyllis Eisenstein, ed., Columbia College Chicago (Fiction Writing Department, 600 South Michigan Avenue, Chicago, IL 80605-1996; order "Attn. of SPEC-LIT Fulfillment"), $6.95, 175 pp. (ISBN: 0-932026-45-1).
Yes, We Have No Neutrons, A.K. Dewdney, Wiley, $22.95, 180 pp. (ISBN: 0-471-10806-5).
The Loom of God: Mathematical Tapestries at the Edge of Time, Clifford A. Pickover, Plenum, $29.95, 292 pp. (ISBN: 0-306-45411-4).
The Encyclopedia of Fantasy, John Clute and John Grant, St. Martin's, $75, 1049 + xvi pp. (ISBN: 0-312-15897-1).

I've plugged it before (last March), so I don't really want to review it in full. But let me say that E.C. Tubb's **The Return** is now in my hands, and if it's a pretty typical Dumarest of Terra yarn, this is indeed the one where Dumarest finds Earth. At least, at the end he has just blown the last obstacle out of space—the Cyclan was actually waiting for him!—and he's in orbit looking down. But plenty of mysteries remain, and Tubb could easily spin the series out for another 32 books.

It's really a shame that no one ever picked this up for TV. It would have made a better series than many we've seen. It still could.

For fans, there's a plus in Tubb's own summary of Dumarest's career, as well as Philip Harbottle's introductory essay.

Steven Gould made fans and a good impression with his first novels, *Jumper* and *Wildside*. His wife, Laura J. Mixon, had a similar effect all her own with *Glass Houses*. Now, together, they give us **Greenwar**, an action thriller that uses Steven's experience as a salvage diver, and Laura's as an environmental compliance manager, and

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moves very nicely but ultimately leaves the reader wishing for a bit more explanation of the villain's motivation.

The tale begins as eco-activist Gabriel Cervantes is blowing up a polluting factory in the American Southwest. He is promptly arrested, but soon an expensive lawyer shows up to say another factory has been blown up in the name of his outfit ("Wild Justice"), he has an alibi, and would he please attend a meeting? Soon he has been enlisted by mystery lady Boadica to help destroy Gulfstream I, a corporate structure built to extract energy and food from the sea in a maximally non-polluting way, apparently because it has more conventional corporate money behind it and because it represents the Big Nasty, technology.

Meanwhile, a hurricane is bearing down on Gulfstream I. Engineer Emma Tooke, who designed the place, is leading the struggle to batten down all hatches with the aid of her dedicated crew and a brand-new environmental manager, Keith Hellman; even as political slimeball scientist Thomas Reynolds seeks to gut Gulfstream's "green" components to build his own empire and a major partnership with GM to build hydrogen-fueled cars collapses, threatening the company. Hellman, who is actually a plant, working for both the EPA (hunting for bribes to environmental regulators) and the FBI anti-terrorism squad, soon realizes just how dedicated the crew is and falls for Emma. Emma falls for him. The FBI anti-terrorists, however, know that Cervantes is on the loose and that he and Emma were once a big item. Emma has a clerk run a background check on Hellman and learns that certain things don't match up. Love is thwarted.

Meanwhile, Cervantes and Boadica are on their way, making plans, building bombs. And the reader knows very well, after all the hurricane hoorah, just how fragile Gulfstream is, and just how a few well-placed bombs could do it in.

So this has all the makings of a thriller adventure, it's a natural buy for Hollywood, there's an obvious hook at the end for a sequel (think of all the pulp villains who ever returned to sneer again), and you'll enjoy it. But perhaps you will join me in a few technical quibbles (after all, this is *Analog*). For one thing, some of the thriller tension depends on a definite weakness in Emma's hotshot design for Gulfstream I: a catwalk overhangs flotation chambers whose walls have not been constructed to withstand a hit from a falling catwalk (the answer could be the same double hull long urged for oil tankers), and Murphy's Law guarantees that the hit will happen. For another, the authors play a bit with the explosive potential of a barge full of hydrogen generated by Gulfstream's OTEC (Ocean Thermal Energy Conversion) power plant but only briefly mention the toxicity of the plant's ammonia working fluid (which if released all at once—remember those bombs—could play havoc with people in the vicinity). For a third, in the real world, OTEC seems to have faded out of serious contention as an energy technology because of major efficiency problems

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(a few barnacles in the pipes, and you're running at a loss).

You say most folks won't notice? OK, I'll shut up, except to say I don't think there's a thing here to bother "most folks." And the basic message, that the technological Big Nasty can do things right and that anti-tech fanatics need not be on the side of the angels, is one well worth the attention of "most folks," far too many of whom seem far too ready to identify business and technology with the forces of evil.

As the authors note, ". . . So many environmental protesters exaggerate the risks. And they get their facts wrong—to the point that it looks as if they're deliberately distorting the situation. . . . And half the time they don't understand the businesses they act out against. They seem to think they're dealing with a bunch of monsters, evil polluters, not other human beings. They don't understand the real issues involved." This is very true and very sad. It is also one of the major reasons why the small business college at which I teach (Thomas College, http://www.thomas.edu) has begun adding a sizable environmental component to its undergraduate business management degree programs.

Paul Preuss's **Secret Passages** has a great deal to recommend it, including a connection to the physics of *Analog*'s own columnist, John Cramer, who is in turn the author of the very next novel in this column. And perhaps that's enough for a few of you, who savor the deep connections or "secret passages" among the various segments of science and science fiction.

For the rest of you, who would rather know a bit about the novel, *Secret Passages* concerns one Manolis Minakis, an elder physicist who has a project for which he recruits younger hotshots. Said hotshots tend not to stay very long, but now he has his eye on Peter Slater, who has turned from insightful work in conventional quantum physics to philosophical physics in search of a solid reality. Peter's new wife, Anne-Marie, is a photographer with a past, with an ex-husband who insists on custody of the son he thinks is his but Anne-Marie knows was sired by her rapist brother, Alain, a dealer in antiquities. To get her on his side, Minakis offers photos of Minoan treasures, bait that Anne-Marie can use to pry evidence of paternity from Alain.

And off we go on a tour of Crete and its Minoan relics, of Minakis's origin as the bastard son of a shepherd lass and an unknown father—brilliant enough to attract the attention of English archeologists and gain an education; of Crete's encounter with the Nazis in World War II; of an ancient cave full of human bones and artifacts of many ages. Eventually we come to what makes the novel SF, for Preuss is using Cramer's transactional interpretation of quantum mechanics to say that if we know the past we can rewrite or refine or improve the present, at least in small ways. Minakis's project deals with this in a physical way. The novel itself is more figurative, dealing in lives and attitudes more than with objects. In both senses, Preuss succeeds very nicely.

The only real stopper comes late in

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the novel, when Anne-Marie makes a sudden and totally unjustified leap to say that Minakis's mother and her lover had had their assignations in the treasure cave. The evidence for this does exist, but they haven't found it yet. And the cavern is so difficult of entry that I doubted it even then.

Oh, well. It comes late in the tale. By then, one is willing to forgive a bobble or two. I still commend it to your attentions.

John Cramer's **Einstein's Bridge** is a very different sort of tale from Preuss's, yet it is also a historical novel of a sort. The history is more recent, however; Cramer tells us in his initial "Acknowledgments" section that it was originally intended to be a hard SF novel set in and about the Superconducting Super Collider once planned to be built in Texas. Indeed, it was nearly done when, in 1993, Congress canceled the SSC for good and all.

As a physicist, Cramer was, of course, heartbroken. He had planned to do some interesting work at the SSC. As a writer, he was heartbroken again, for his baby no longer had much point. Eventually, however, after a thorough rewrite, Cramer came up with *Einstein's Bridge,* which tells us the *real* reason why Congress killed the SSC. In this Universe, anyway.

The opening scene tells us of the Hive Mind, an insectile species that developed intelligence, reached the stage of high-energy physics, discovered a pathway to a neighboring universe inhabited by another intelligence (just one—intelligence is rare), killed it off, and moved in. And then it did it again. And again. Until some unknown factor stymied it.

OK. The SSC was to deal in the highest-energy physics Earthfolk had yet touched. A wise reader might well stroke his or her chin, mutter, "Hmm!" and expect the SSC to draw the Hive's attention, as well as that of the unknown stymier (revealed as another species, represented by Tunnel Maker, in Chapter 3). But first meet George and Roger, physicists working with the SSC. Meet Alice, a writer of horror-bug novels, on her way to Texas to infiltrate the SSC, make friends (with George, for instance), collect dirt, and research her next, all about fire ants mutated by strange SSC radiations into giant, voracious gotchas (don't forget that Hive Mind—Alice's mission is far too apt!).

Tunnel Maker has detected high-energy events at the SSC and is waiting for the next so he can do his job. The SSC is down for the moment, however, giving the characters time to get into place and Cramer time both to give his readers a thorough tour of the SSC that might have been and to explicate some interesting physics (including his transactional interpretation of quantum mechanics). When it finally powers up, Tunnel Maker acts, George and Alice spot an inexplicable event in the detector, and in due time there is a link between the universes.

Tunnel Maker has a great deal of information to give, but he also has a warning to issue about the Hive. The SSC crew should be watching for another inter-universe link; if they miss it, Earth will be stripped of life and

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turned into another Hive.

Einstein's Bridge thus has a great deal of action-suspense-thriller potential. It even lives up to it, moves right along with nice momentum, and delivers enough satisfaction on that level to warrant a recommendation.

But as I hinted earlier, there's more to it than that, and to do the novel, Cramer, and his purpose justice, I now have to say what some of you may think too much. Therefore:

SPOILER WARNING!!

Of course, the SSC crew misses the signal until too late. How else could Cramer segue to his point?

That point becomes abundantly clear when Tunnel Maker successfully shunts George and Roger into our Universe (well, maybe), where they use the ample resources they have been given to stop the SSC and save Earth from the Hive. Which actually makes about as much sense as the jackasserie—amply reflected in Cramer's frequent quotes, as well as in the Afterword—that marked the actual history of the SSC's murder.

The end result thus offers plenty of futuristic, alternate universe excitement, but it then takes us beyond the standard SF approach to explain why the present is the way it is, at least in one respect.

Peter S. Beagle returns to the world of *The Innkeeper's Song* with **Giant Bones**, a half-dozen stories featuring places and people familiar from that novel. Here too is a very familiar voice, that of the marketplace or fireside or bedside storyteller saying, "Listen up, while I tell you of "The Last Song of Sirit Byar," that wandering bard whom I accompanied in my youth, and who could move minds to madness, or to. . . . Or would you prefer the tale of "The Magician of Karakosk," untutored in his art but so talented that the Queen of Fors na'Shachim herself snatched him from his hovel to teach her the path to greater wickedness. Not that it helped her much. Or there's "The Tragical Historie of the Jiril's Players," and why no wandering repertory troupe now dares to visit Derridow. Or "Lal and Soukyan"—remember them?—who in their elder days embarked on a mission of atonement, Lal leaving behind her an apprentice storyteller who will a little later emerge from behind that curtain—yes, that one, right there—to relate "Choushi-Wai's Story," concerning the maiden Tai-sharm, who thought she thought too much, and the Thief (that was all the name he was known by in those days and in those parts) who rescued her from the king. And oh, yes, the Singing Fish; we mustn't forget that crucial character of the tale.

"That's only five? Then you can count, my boy, but still you should be in bed. You insist on a story? Well, I can't do it as well as your mother, but perhaps I could tell you why we in this family are so tall. It has to do with your great-great-great-grandfather Selsim, who was taken captive by the Giants and never escaped till the last of them was dead, and yes, he did take a crucial part of them away with him. That one's called 'Giant Bones,' and it's really quite nice."

You say you can't choose just one?

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You want them all? Then you'll have to buy the book. And then no one will see you for a day or two while you sit in a corner and gobble them all. Please, however, do be sure you have a good light shining over the left shoulder and remember to pause once in a while for a bite to eat and a drop to drink. I'll see that there's a pot on the stove and a keg in the cellar.

You can find some rather nice amateur writing in **Spec-Lit No. 1**, which presents some of the best work done over the last few years by students in Phyllis Eisenstein's SF-writing class at Columbia College Chicago. Indeed, to call this small bookzine's content "amateur" is perhaps to dignify that term a bit beyond its usual status. Either Phyllis has had some unusual students or she has done some unusual things with them, for many of the stories here are at least up to semi-pro level. The most amateur thing about these folks is that when they finished Phyllis's course, most of the stories went into a drawer until Ye Ed called. Perhaps this experience will convince a few to try again.

For those who want something more than "amateur" writing, no matter how readable it is, *Spec-Lit* also contains Gene Wolfe's "The Changeling" and Algis Budrys's "Living Alone in the Jungle," a nice little tidbit about the value of assassin-bait that sounds almost like it was written by the late Mike Royko. Both Wolfe and Budrys have also taught SF writing at Columbia College.

May I call your attention to A.K. Dewdney's **Yes, We Have No Neutrons**? Dewdney is a math prof at the University of Western Ontario, has been a *Scientific American* columnist, and has written a number of books, most of them popularizations of science. Here his theme is "bad science," meaning not fraud but error of a very particular kind. Science is bad when its proponents lack a certain critical keenness and are blinded to the criticisms of others by their own enthusiasm. And there's plenty of it around.

Among Dewdney's examples are several—N rays and cold fusion, Freud's unconscious and racial bell curves, even neural nets—with which I have little problem. However, I do think he and others treat Biosphere 2 unfairly (especially when he dismisses one of its basic justifications by saying dismissively, "Who but space cadets would want to live on Mars anyway?"). Intelligence is a fuzzy concept and intelligence tests have been misused, but I don't think this implies that intelligence cannot usefully be tested; Dewdney doesn't mention Shockley's pattern-matching test of information processing efficiency.

And then there's SETI, the search for extraterrestrial intelligence. How dare he call this favorite of mine and yours bad science! More seriously, I balk just a bit at the statement that even if SETI succeeds, that won't make the science less bad. In general, when a topic in science starts off cursed by overenthusiasm but the data do turn up, it is promptly converted into "good" science and academic specialties spring up around it.

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For an example, consider the once very strange notion that rocks could fall from the sky; today we call them meteorites.

I suspect Dewdney is not a science fiction fan, but the book is worth reading by such fans even if it will annoy them. One of the main reasons why is surely that it succeeds in its intention of encouraging a skeptical attitude toward breathless claims and reminds us that not all science fiction is labeled "story."

Clifford A. Pickover coined "theomatics" to mean "the blending of mathematics and religion." In **The Loom of God: Mathematical Tapestries at the Edge of Time**, he endeavors to show us how ancient that blending is by going all the way back to Pythagoras, who founded a cult based on the divine significance of numbers and their patterns (it also pushed the transmigration of souls and forbade the eating of beans). Using time travel as the unifying gimmick, he and his diamond-shelled buddy, Mr. Plex, hide out in a temple's unused back room to eavesdrop on Pythagoras, discourse on triangular and pentagonal numbers, gnomons, Stonehenge, fractals, kabala, and a great deal more, and pick up Pythagoras's wife, Theano. In case you doubt that he tells you true, he alternates bits of obvious fiction with equally obvious nonfiction on math, history, and religion; in an appendix, he provides the code for several short computer programs that can allow you to play with some of the ideas he presents. The end result is both entertaining and edifying, aimed chiefly at those without much mathematical talent but with enough "theomatic" lore to be interesting to everyone.

If you have used the Clute/Nichols *Encyclopedia of Science Fiction,* you have a pretty good idea of what to expect from **The Encyclopedia of Fantasy**, edited by John Clute and John Grant: over a thousand pages of entries on the authors, themes, motifs, films, and more. It's not the sort of thing a reviewer can read before commenting, but let me try a couple of spot checks:

MUD or Multi-User Dungeon—no entry, though there is a definition buried within the "Games" entry.

Silver Web—no entry, though there are for *Cemetery Dance* and other magazines.

So it's not perfect. Neither was *EoSF,* but at least that one came with supplemental sheets. In both cases, the basic problem is that even a thousand-page whopper of a reference book is still finite. What *is* here is more than enough to make the book an essential addition to the library of anyone who wants to look up something about the fantasy field more than, say, twice a year. If you're a librarian, you *have* to have it.

Do you want it in this form? At the moment, this is the only form you can get it in, but surely it's only a matter of time before *EoF,* like *EoSF* before it, is available on CD-ROM for your computer. Maybe they'll even put both tomes on one disk. ■

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Dear Stanley Schmidt:

The issue with your editorial "A Bad Time for Aliens" (May 1997) arrived only a couple of weeks after the Heaven's Gate thirty-nine left their "containers" at Rancho Santa Fe to join presumably friendly aliens in a spaceship following in the shadow of Hale-Bopp. That's hardly a "fashion calling for making aliens almost automatically the Bad Guys."

The Heaven's Gate cult may, you can argue, represent a near-psychotic extreme in our population. But the incredibly positive reception given to the "enhanced" *Star Wars* trilogy, which portrays far more friendly and helpful aliens than it does monsters like Jabba the Hutt, suggests to me that your examples of *Independence Day* and *Dark Skies* are more the anomaly than the rule. The same message, I believe, is sent by the popularity of *The X-Files*, in which the aliens seem to be more victims of a world-government conspiracy than "the new enemy."

The film *Mars Attacks!*, which was announced after your editorial was written, might furnish some evidence for your thesis. But it is a comedy, and its big-brained Martians cannot be taken seriously as an "enemy." Indeed, though the aliens of *Independence Day* are certainly a highly destructive enemy, that film too (which was the acknowledged stimulus for *Mars Attacks!*) was more tongue-in-cheek than serious.

There is, however, a widely perceived new "enemy." Walt Kelly's Pogo once said, "We have met the enemy, and he is us." In the *Star Wars* trilogy the true and frightening enemy is no alien, but our own "dark side": Darth Vader and the Emperor. In *The X-Files* the enemy is Cancer Man and his colleagues in our government and around the world. And, even more explicitly, in the *Millennium* series the enemy is the frightening potential for evil in the ordinary human being.

Carl Jung argued decades ago that the human psyche cannot fully realize its potential until it faces and integrates its own Shadow. I would like to think that the evidence I've cited shows our society in the process of facing its Shadow, the Dark Side of its Force, and that we will emerge into a less drastic "Childhood's End." But I'm old enough not to expect that emergence too soon. . . .

BRUCE A. BEATIE
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The "Star Wars" re-release phenomenon has a strong component of nostalgia. My observation still seems to me to apply to a disproportionate share of the new work being produced now.

Dear Dr. Schmidt:

My thanks to Dr. Charles Sheffield (May 1997) for finally telling me, and millions of other writers, what we do every day. Being only a humanist, I've always defined the process, to myself and my writing students, as "choice." But, as Sheffield makes clear, and as I realize writing this letter, my poor biological computer is actually searching the lexicon of English for a few million words out of which I can pick the right one. That this process suddenly collapses into just the right word (don't we all hope!) illustrates what Mark Twain said some years ago: "The difference between the right word and the almost-right word is the difference between lightning and the lightning bug."

PATRICK J. O'CONNOR
Danbury, CT

Dear *Analog*,

I would like to offer a couple of discouraging thoughts about DNA computation. In this discussion, I have used powers of ten with great abandon, since errors of even quite a few powers of 10 change the conclusions not at all.

10^{156} is a damn big number. (vide Beowulf Shaeffer on his use of profanity for emphasis). If we need just one DNA molecule for each configuration, two big problems arise. First, it would require vastly more atoms than those available in the entire universe (10^{70}). Putting that relatively minor problem aside, consider the ullage. DNA solutions (solutions are required to carry out the chemistry) are limited to about 1 M/liter. That symbol M means Avogadro's number, 10^{24}. Thus, to contain the DNA, we would need a beaker holding 10^{132} liters of water. Ignoring the water shortage, this beaker would be 10^{43} meters on a side. A light year is 10^{13} meters, so this beaker would be 10^{30} light years in diameter, vastly larger than the known universe (10^{10} light years).

People writing about DNA computation, e.g. Adelman and Lipton, come from computer science where the law of the excluded middle holds sway; zeros and ones as far as the eye can see. Chemistry is a lot sloppier. The non-covalent interactions of DNA=A0 chemistry have best-case affinities in the range of nanomolar (10^{-9} molar). For non-chemists, that means that when you have 10^{9} molecules of pure stuff only half of it is bound. 10^{-9} molecules is 10^{-15} M, an exquisitely small amount from the perspective of chemical analysis in the presence of impurities of a similar nature exceeding it by 10^{15} in a 1M solution. Above, we were speaking as if 1 molecule of DNA=A0 per configuration were sufficient. To get high accuracy binding, we will need a lot more than that, 10^{12} to get 99.9% (chance of error .1%) and preferably a lot more identical molecules for each configuration. Let's be clear about what a .1% error rate means; it means 10^{153} incorrect molecules. The impli-

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cation is that we need a trillion times more stuff, and barrels a million times larger than suggested by the initial analysis ignoring errors.

And things are getting worse by the second. We have not yet considered how long DNA=A0 computation might take. Even in the lab with small volumes, the chemistry implied by the computation proposed by Adelman for seven cities would take a matter of weeks using current technology. Serious effort could speed up the process a lot, but we are never going to be doing this on a time scale of seconds. Since the parallelism of all those DNA molecules equilibrating at the same time makes that part of the process quite fast, most of the time is for setup and separation. As the number of cities goes up, and with them, the number of very similar molecules among which discrimination must be made, these separations, which are the heart of the process, become increasingly delicate and therefore increasingly time-consuming as well as error-prone.

Evidently, no one is going to be attempting to solve the traveling salesman problem for 100 cities with DNA any time soon.

I guess what bothers me most about the DNA=A0 computing speculation is that anybody with a modicum of chemical knowledge can see these roadblocks after thinking about the problem for a few seconds. To pretend that they do not exist can hardly even be called disingenuous. 10^{156} is a damn big number.

Before abandoning the idea of DNA=A0 computation altogether, we might sit and think a bit about what sorts of problems could actually be solved by real-world amounts of DNA, i.e. 10^{24} molecules. This is still a big number, and it is very much larger than the number of people on the earth (10^{10}), the number of cells in the human body (10^{15}), and comparable to the number of multicellular organisms on the Earth. A major undertaking, comparable to the Human Genome Project, could establish a one-to-one correspondence between some attribute of such a substantial population and a pot of DNA (or maybe 10^3 pots; we are talking industrial scale, here, but not Ringworld Engineers). We now have a small enough problem that there can be enough copies of each DNA type to do accurate chemistry. A typical attribute is possession of a certain DNA sequence. This could be coded by the actual sequence. The remainder of the DNA molecule would code for the individual (person, cell, organism, etc.) who provided it. By passing this database through a column containing a complementary DNA sequence, we could select all the individuals who had that sequence. The current technology for performing such searches uses digital computers and large disks to hold the sequence libraries. As the number of sequences grows, this technology is becoming increasingly strained. There might be a place for DNA computing in this process. Techniques analogous to this are already being used for drug discovery.

BARRY BUNOW
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Dear Dr. Schmidt:

This is the first time I've ever written to you. I've been reading and enjoying *Analog* and its predecessors for longer than I care to admit. Let's just say that this little vice predates my first slide rule (Yes, I still have one. Cost me a bloody fortune at the time, and I'm bloody well not giving it up! Anyway, it needs no batteries . . .) Please allow me to stroke your ego by saying that I've enjoyed most of the stories in *Analog*, and every single one of your editorials. Though I realize that you probably enjoy a good argument, I'm afraid that I almost invariably agree with your Occam's Razor-style points of view.

I would like to express appreciation for Charles Sheffield's excellent article, "Deus Ex Machina," in the May 1997 *Analog*. I use computers extensively and have come to take for granted the usual improvements in cost and performance. Though amazing in the historical perspective (I started with a PDP-8 with 8K of RAM), these are really merely engineering improvements of an old technology. But I really enjoyed the "insights" into radically different approaches to computing that were presented in this article, such as biological and quantum computers. Great food for thought!

Having said the above, it is almost with embarrassment that I must point out that the example used for biological computers doesn't make sense. Though the example given will indeed provide an accurate solution to the "Traveling Salesman Problem" for 5 cities, it can not work for 100 cities. To solve the problem as stated, DNA strings must be combined in every possible combination. As Mr. Sheffield points out, the total number of possible solutions is 99 factorial. Even assuming 100% efficiency, ie. only one string for each possible solution, no incomplete strings, no endless repetitions, etc., which is obviously impossible, this would require an absolute minimum of 10^{156} DNA strings.

A highly unscientific, back-of-the-envelope estimate tells me that our entire known Universe is made up of a total of only something like 10^{76} atoms. Even if we throw in some dark matter and this guesstimate is off by a factor of trillions, this would only bring it up to 10^{88}. So coming up with 10^{156} DNA strands is going to present a bit of a technical challenge. Never mind a beaker big enough to hold all this stuff and finding some way to stir it all.

So I'm afraid that mere "billions and billions" of DNA strands just won't do.

Again, it was a great article and I enjoyed it immensely. The concepts presented were very thought-provoking. Frankly, I hope I missed the point and that Mr. Sheffield's example is correct after all.

EGON H. VARJU, P.ENG.
Vancouver, Canada
egon@varju.bc.ca

Dear Stan,

I don't disagree at all with any of Barry Bunow's or Egon Varju's numbers. In fact, letters similar to theirs appeared in *Science* magazine soon after the publication of Leonard Adleman's original 1994 article. One of them was actually by Barry Bunow himself (*Science*, 28 April, 1995).

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However, I don't accept their conclusions. In fact, as Mr. Varju suggested, an argument from numbers somewhat misses the point of my article.

Certainly, no one in his or her right mind would employ DNA computing to tackle the Traveling Salesman problem by direct enumeration of routes. There are far better methods, even if they do not in all circumstances guarantee an absolutely optimal solution. Most examples are chosen to illustrate a point rather than to solve a real-world problem. Thus, I picked the familiar Traveling Salesman problem to show that DNA manipulation can be used as a computer with high parallelism, something which most people would not consider at all obvious.

What is the future potential of DNA computing? I do not know; nor does anyone else. But looking at the current state of DNA computation, with its very limited "instruction set," and concluding that it won't work for real-world problems, is rather like complaining that the Wright Brothers' airplane in its original form could not fly like a 747.

DNA computing is in its absolute infancy. Barry Bunow gives one example of what a slightly different DNA matching procedure might do. Hundreds or thousands of other practical uses will surely be found in the next decades.

CHARLES SHEFFIELD

Dear *Analog*,

Thanks for printing my note about authors' names at the bottoms of pages, and for asking for votes. I was also pleased that some people sent me copies of their responses to *Analog*.

There is a problem in the illustration for Janifer's "The Dead Beat" in the June 1997 *Analog*.

The picture includes an oscilloscope-type view of the musical beat featured in the story. There is an extra kink in it that doubles back—impossible in such a display. The artist could see why by wiggling a pen from side to side while pulling a piece of paper under it.

J.A. COFFEEN

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Oops! You're quite right, and at least someone knew it. I'm not sure how that one slipped through.

Dear Readers:

I wanted to take a moment to thank those of you who enjoyed "The Three Labors of Bubba" enough to have chosen it Best Novelette of 1996 in the annual Analytical Laboratory this year.

Astounding/Analog formed a significant portion of the SF I grew up reading, and I am both honored and delighted to have found an appreciative audience amongst its readers. Thank you all.

And, for those of you who've asked me if the Gentleman Mechanic from Virginia will be back, the answer is yes—but probably not the way you might suspect!

BUD WEBSTER

PS: For anyone who's interested, I have Saucer Nuts of America T-shirts available. Please write to me, care of *Analog*, for more details. ■

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UPCOMING EVENTS Anthony Lewis

28–30 November 1997
CONCAT 9 (Knoxville area SF conference) at Radisson Hotel, Knoxville, Tenn. Guests of Honor—Barbara Hambly and George Alec Effinger; Artist Guests of Honor—David and Lori Deitrick; Special Guest of Honor—Patricia Kennealy Morrison. Registration—$25 until 10 November, $35 at the door. Info: ConCat 9, 316 East Scott Ave., Knoxville, TN 37917. (423) 637-6562. Email: ChloieA@aol.com

5–7 December 1997
SMOFCON 15 (SF convention runners' conference) at Doubletree Suites, Boston, Mass. Theme: "When Things Go Wrong" Registration—$35 until 7 September 1997, more thereafter; checks payable to MCFI. Info: SMOFCon 15, Post Office Box 1010, Framingham, MA 01701-1010. FAX: +1 617 776-3243. Email: info@mcfi.org URL: http://world.std.com/~sbarsky/smofcon.html

25 December 1997
POLECON MCMXCVII (High Arctic SF conference) at The Workshop, Ninety North. Narnia Guest of Honor—Jill Pole; Artist Guest of Honor—John Frost; Special Guest of Honor—Pepe le Pew. Registration—free, but restricted to good little girls and boys (we know who you are!)

16–18 January 1998
CHATTACON XXIII (Chattanooga area SF conference) at Clarion River Plaza, Chattanooga, Tenn. Guests of Honor—Jack Vance and Howard Waldrop; Special Guest of Honor—Terry Bisson; Regional Artist Guest of Honor—Julia Morgan-Scott, TM—Charles L. Grant. Info: Chattacon XXIII, Box 23908, Chattanooga, TN 37422-3908. Email: chattacon_info@mindspring.com

5–9 August 1998
BUCCONEER (56th World Science Fiction Convention) at Baltimore Convention Center and nearby hotels, Baltimore, Md. Guests of Honor—C. J. Cherryh, Milton A. Rothman, Stanley Schmidt, and Michael Whelan; TM—Charles Sheffield. Registration until 30 September 1997—$110 (80); supporting $30 (22); children +4 to +12 $55 (40), children—0.75 to +4.0 FREE (all ages as of 5 August 1998). This is the SF universe's annual get-together. Professionals and readers from all over the world will be in attendance. Talks, panels, films, fancy dress competition—the works. Info: Bucconeer, Post Office Box 314, Annapolis Junction, MD 20701. Email: baltimore98@access.digex.net Web page: http://www.access.digex.net/~balt98

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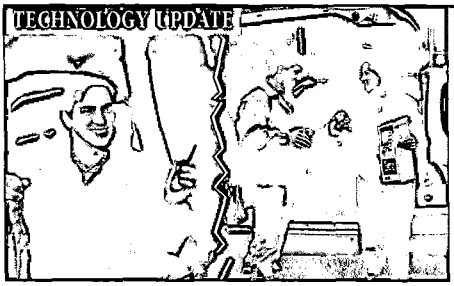


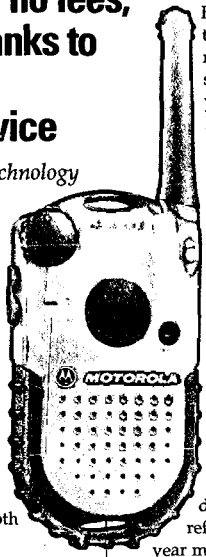
Two-way talk, with no fees, is now possible thanks to this powerful new communication device

Motorola integrates microchip technology into a palm-sized two-way radio to create the ultimate communication device.

Picture this...you're on a camping trip with your family. It's getting dark, and the kids haven't returned from "exploring." Split up and try to find your children? No...you simply turn on your Motorola Sport Radio, push a button and tell the kids to return to camp and get to bed. These radios are the ultimate in personal communication, with literally hundreds of uses, both practical and fun.

Wireless freedom and safety. Hand-held personal communication devices have been around for a long time. Unfortunately, the technology had not advanced to the point that they could be made small, powerful and affordable. The only way to get clarity, power and durability in personal communication was to use expensive cellular phones, with sky-high usage fees and limited coverage in rural areas...until now.

Crystal-clear and convenient. Motorola, the world's leader in wireless two-way communication, has integrated the latest electronic technology into a product that operates on the Family Radio Service (FRS) bands. The radio can be tuned to any one of 14 UHF frequencies and 38 interference eliminator codes, so you can pick any channel you want, without experiencing the annoying interference that you get from CB radios. The powerful circuitry and unique antenna design enable crystal-clear reception for a two-mile range. Because you get to pick the transmission channel, as many friends and family members as you like can stay connected. The only limit is the number of radios you have!



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